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MEAL MODULE, TRAY PACK 36-PERSONS

BY

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19 ABSTRACT (Continue on reverse if necessary and identify by block number) <p>➤ To significantly increase the efficiency of the Class I distribution system, while reducing dedicated Class I manpower, the U.S. Army Natick Research, Development and Engineering Center (Natick) was tasked to develop an optimal meal module size based upon standardizing the number of Tray Pack portions per tray. The meal module consists of all food, disposables and eatingware to comprise a specific meal for a predetermined number of soldiers.</p> <p>Natick analyses determined that standardizing the number of portions per tray at 12 and 18 provided an optimal solution. These analyses were provided to and accepted by the U.S. Army Office of the Deputy Chief of Staff for Logistics and the U.S. Army Troop Support Agency in July 1985.</p> <p>The Meal Module, Tray Pack, 36-Persons consists of two fiberboard containers strapped together providing Tray Packs, condiments, and disposable eating and serving ware to subsist 36 personnel for a specific meal. The maximum weight for the meal module is about 96 pounds evenly distributed between the two containers. Each container has dimensions of 23.75¹¹(L) x 13.00¹¹(W) x 8.75¹¹(H). Both containers are strapped together to form a meal module with</p>					
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dimensions of 23.75^{in.}(L) x 13.00^{in.}(W) x 17.50^{in.}(H). Twelve (12) of the same menu meal modules comprise a MILVAN pallet load. Volume utilization of the pallet load is about 96%. Weight is about 45% of the maximum allowable per pallet. Pallet loads are stackable four high. The palletized meal modules are air-droppable.

SUMMARY

BACKGROUND

Army field feeding to support the new Light Infantry Divisions (LID) and other restructured divisions of the Army of Excellence (AOE) will significantly differ from prior field food service operations. The new Army Combat Field Feeding System (CFFS) provides a highly mobile, tactically responsive food service capability for preparing a minimum of two hot meals per day. The primary food component of the CFFS is the Tray Pack. The Tray Pack is a high quality, fully prepared, shelf stable food product packaged in a metal half-sized steam table tray. A sufficient variety of Tray Packs is available to support a 14-day breakfast and dinner cyclic menu.

Food handling and preparation requirements at the food preparation point have been reduced through the usage of Tray Packs. Therefore, employment of the CFFS allows for streamlining the operations of both Food Service Specialists (MOS 94 Bravo) and Subsistence Supply Specialists (MOS 76 X-Ray). To significantly increase the efficiency of the Class I distribution system while reducing dedicated Class I manpower, the U.S. Army Natick Research, Development and Engineering Center (NRDEC) was tasked to develop an optimal meal module size based upon standardizing the number of portions per Tray Pack. The meal module was to consist of all food, disposables, and eatingware to comprise a specific meal for a predetermined number of soldiers.

GUIDELINES

The U.S. Army Troop Support Agency (TSA) provided guidelines used in the analyses. Parameters fell into two general categories as detailed below.

1. Menu Guidelines

- a. MENU. Utilize the TSA 14 day menu cycle and Tray Pack products of Combat Field Feeding System-Field Feeding Concept-Field Development Test and Experimentation (CFFS-FFC-FDTE) as the baseline menu.
- b. COST MINIMIZATION. Minimize the average meal cost per person over the CFFS-FFC-FDTE menu.
- c. NUTRITIONAL. Maintain nutritional standards.
- d. CLASS I ISSUE POINT. Design a meal module for distribution to the Mobile Kitchen Trailer.

2. Meal Module Size Guidelines

- a. **FORCE STRUCTURE.** Determine one meal module size to satisfy both heavy and light infantry division requirements.
- b. **HUMAN FACTORS.** Design a meal module capable of being on/offloaded by one female MOS 94 Bravo.
- c. **PALLETIZATION.** Minimize the weight and cube of a meal module and maximize utilization efficiency of a standard military van (MILVAN) pallet.

RESULTS

A data base was designed and software developed to analyze portion and meal module size alternatives. All portion alternatives considered were determined to be nutritionally adequate by the Nutritional Research Task Force, U.S. Army Research Institute of Environmental Medicine (ARIEM). Natick analyses determined that 12/18 portions per Tray Pack provided the best alternative for portion standardization. The number of portions per Tray Pack is established at 12 for products with specifications of less than 18 portions per tray. The number of portions per Tray Pack is established at 18 for all other products. These analyses were provided to and accepted by the U.S. Army Troop Support Agency.

Of the many alternatives evaluated, a meal module to subsist 36 persons was determined to be the optimal size. A minimum average meal cost per person of \$1.89 for a Light Infantry Division and \$1.91 for a Heavy Division was achieved at the meal module size of 36 utilizing the 12/18 portion alternative. The Class I issue point was the Mobile Kitchen Trailer.

The Meal Module, Tray Pack, 36-Persons consists of two fiberboard containers strapped together providing Tray Packs, condiments, and disposable eating and servingware to subsist 36 persons for a specific meal. The maximum weight for the meal module is about 96 pounds evenly distributed between the two containers. Each container has dimensions of 23.75"(L) x 13.00"(W) x 8.75"(H). Both containers are strapped together to form the meal module with dimensions of 23.75"(L) x 13.00"(W) x 17.50"(H). Twelve of the same menu meal modules comprise a MILVAN pallet load. Volume utilization of the pallet load is about 96%. Pallet load weight is about 45% of the maximum allowable.

Drop, vibration and compression tests of internal and external pack and packaging for both the meal module containers and the entire pallet load have been successfully completed. Pallet loads are stackable four high. Airdrop rigging procedures have been developed.

Requisitioning of meal modules from the Class I supply system began in April 1986.

PREFACE

During FY86 the Systems Management and Logistics Branch, Systems Engineering Division, Food Engineering Directorate of the U.S. Army Natick Research, Development and Engineering Center designed and developed the Meal Module, Tray Pack, 36-Persons. This military service requirement AM 88-2 was conducted under Production Engineering in Support of the Food Program, project number P728012.19. Accomplishment of this project required the cooperative efforts of many individuals. Specifically, the authors would like to thank members of the following organizations:

- o U.S. Army Joint Technical Staff at Natick

LTC Jon DeWolfe was instrumental in obtaining needed information as well as providing useful feedback at key points in the project.

- o U.S. Army Troop Support Agency, Fort Lee, VA

The smooth transition of the Meal Module, Tray Pack, 36-Persons into the food service supply system in a timely manner was in part due to the cooperation, concern, and responsiveness of the Food Service Directorate. We would like to acknowledge the following individuals:

- Directorate of Food Service

COL David Dee, GS, Director
LTC Fagan
Mr. Richard Helmer
Mr. Robert Amirault
Ms. Emily Prior

- o Deputy Chief of Staff for Logistics, Department of the Army

LTC Keith Huff (DALO-TST) was our point of contact and always provided timely assistance and responses to all of our requests.

- o Defense Personnel Support Center, Philadelphia, PA

The number of individuals that supported efforts to have the meal module ready for requisitioning to user units on an expedited time schedule is too numerous to fully acknowledge here. Key individuals that were involved throughout the development and implementation phase were:

- Directorate of Subsistence

COL Max Coats, Chief, Technical Operations and Quality Assurance
Mr. Charles Grabowski, Packaging and Packing Branch
Mr. Robert Feltner, Chief, Non-Animal Products Branch
LTC Robert Gaddi, Chief, Contract and Production Division

- o Defense Logistics Agency

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- o Defense Depot Tracy, California

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 - LCDR Roesky, SC, USN, Chief, Bulk Operations

- o U.S. Army Natick Research, Development and Engineering Center

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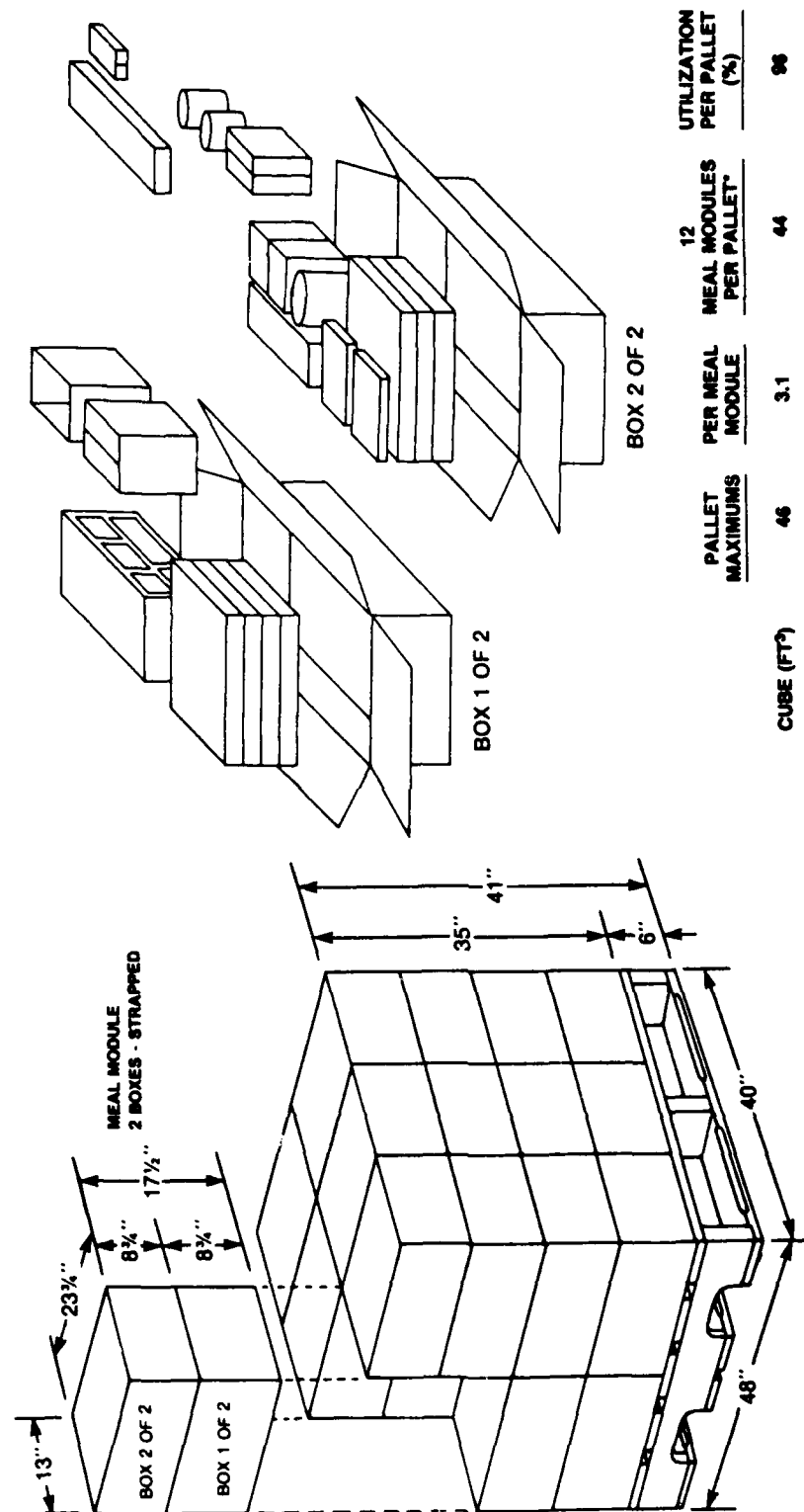
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MEAL MODULE, TRAY PACK, 36-PERSONS



PALLETIZED UNIT LOAD

	PALLET MAXIMUMS	PER MEAL MODULE	12 MEAL MODULES PER PALLET*	UTILIZATION PER PALLET (%)
CUBE (FT ³)	46	3.1	44	96
WEIGHT (LB)	2500	96.0	1225	45
WIDTH (IN)	40	13.0	30	97
HEIGHT (IN)	41	17.5	41	100
LENGTH (IN)	48	23.8	48	99

*INCLUDES PALLET 6" HIGH; 50 LBS

Figure 1. Meal Module, Tray Pack, 36-Persons, Palletized Unit Load

MEAL MODULE, TRAY PACK, 36-PERSONS

SECTION I

INTRODUCTION

Background

Army field feeding to support the Light Infantry Divisions (LID) and other restructured divisions of the Army of Excellence (AOE) will significantly differ from prior field food service operations. The new Army Combat Field Feeding System (CFFS) provides a highly mobile, tactically responsive food service capability for preparing a minimum of two hot meals per day. The primary food component of the CFFS is the Tray Pack. The Tray Pack is a high quality, fully prepared, shelf-stable food product packaged in a metal half-sized steam table tray. A sufficient variety of Tray Packs is available to support a 14-day breakfast and dinner cyclic menu.

Food handling and preparation requirements at the food preparation point have been reduced through usage of Tray Packs. Therefore, employment of the CFFS lead to streamlining of support to current operations along with a reduction in the number of personnel required. However, reductions of both Food Service Specialists (MOS 94 Bravo) and Subsistence Supply Specialists (MOS 76 X-Ray) had important implications on Class I distribution. The Army had noted that inconsistency in the number of portions per tray had created requisitioning and distribution problems for user units. Individual Tray Pack products ranged in the number of portions per tray from 12 to 25. To avert a potential distribution problem, while reducing dedicated Class I manpower on the supply line and at the user unit, the Office of the Deputy Chief of Staff for Logistics tasked the U.S. Army Natick Research, Development and Engineering Center to analyze Tray Pack products with respect to standardizing the number of portions per tray.

The U.S. Army Troop Support Agency (TSA) added an additional requirement to this tasking. Evaluation of preconfigured unitized B rations during the Gallant Eagle 84 and other field exercises indicated that Class I transportation and labor savings were possible through unitization of Class I. Natick was subsequently tasked to integrate unitization into the Tray Pack standardization and develop recommendations for a Tray Pack meal module. A meal module would consist of Tray Packs, condiments, and disposable eating and servingware to subsist a given number of troops for a specific meal. Figure 1 illustrates the configuration for the developed palletized unit load.

The U.S. Army Troop Support Agency (TSA) provided guidelines used in these analyses. Parameters fell into two general categories as detailed below.

- Menu Guidelines

- o MENU. Utilize the TSA 14 day menu cycle and Tray Pack products of Combat Field Feeding System-Field Feeding Concept-Field Development Test and Experimentation (CFFS-FFC-FDTE) as the baseline menu.
- o COST MINIMIZATION. Minimize the average meal cost per person over the CFFS-FFC-FDTE menu.
- o NUTRITIONAL. Maintain nutritional standards.
- o CLASS I ISSUE POINT. Design a meal module for distribution to the Mobile Kitchen Trailer.

- Meal Module Size Guidelines

- o FORCE STRUCTURE. Determine one meal module size to satisfy both heavy and light infantry division requirements.
- o HUMAN FACTORS. Design a meal module capable of being on/offloaded by one female MOS 94 Bravo.
- o PALLETIZATION. Minimize the weight and cube of a meal module and maximize utilization efficiency of a standard military van (MILVAN) pallet.

Technical Approach

Evaluation of the unitized ration concept during the Gallant Eagle 84 Exercise indicated significant advantages for Class I operation in the field through the reduction of MOS 94 Bravo and 76 X-Ray personnel. However, there were shortcomings in the meal modules as configured for that exercise. The Army decided that there was a need to determine an optimum size and configuration for unitized rations using the Tray Pack. Therefore, an analysis of alternative meal module sizes using the guidelines provided was performed to determine an optimal meal module size. The following methodology was used:

- o Develop Data Base. Using the U.S. Army Troop Support Agency T ration menu, nutritional, cost, and portion size information for T rations was collected. A data base was designed and software was developed that would be used in quantitative analysis of alternative solutions.

o Analysis of alternate solutions and selection of meal module size. Using the T ration data base, various analyses were conducted on a range of meal module sizes following the previously discussed guidelines. Based upon these analyses, the optimum meal module size alternatives were determined and presented to USA for their review, concurrence, and selection of a meal module size.

The assembly of meal modules was expected to present several questions pertaining to procedural issues. Analyses were conducted to model the effects of proposed changes to menus, condiment selection, disposable requirements, and palletization. Where proposed changes adversely affected the selected meal module size, recommendations were provided.

o Determine packaging and packing for selected meal module. Various packaging configurations were evaluated by testing the individual meal module containers as well as a pallet load of meal modules. The meal module containers and the pallet load were subjected to drop, vibration, and compression tests. Test variables centered around internal container design changes to strengthen the packaging and packing of items in the same container. The exterior dimensions of the containers were restricted to eliminate overhang on the pallet.

o Develop and test T ration packaging and packing. The selected alternatives were investigated in terms of packaging and packing requirements. Alternative fiberboard and non-fiberboard packing and packaging materials for interior pads and cushioning were investigated. Methods of containerization and various pallet patterns were developed and tested to determine an optimal solution.

o Document meal module assembly. Technical data package (TDP) assembly documentation and drawings were prepared to facilitate the proper assembly of the meal module.

o Develop and test airdrop rigging procedures. Simulated airdrop impact testing was performed at Natick to assist in developing airdrop rigging procedures for a low velocity airdrop using an A-22 cargo bag.

SECTION II

UNITIZATION DATA BASE

INTRODUCTION

The unitization data base consisted of three distinct elements linked together for mathematical analyses. Separate data bases were designed for menu, nutritional, and force structure analyses. Data base operations are outlined in this section.

Menu Data Base. Tray Pack, beverage and condiment information including National Stock Number (NSN), specification portions per tray, product cost, weight and volume were included in this data base (Table 1).

TABLE 1: Example of Menu Data Base Information

Nomenclature	NSN	Product		Volume cuft	Portions Per Tray
		Cost* \$	Weight lb		
Roast Beef	8940-01-150-2857	17.50	7.8	0.19	20
Potatoes in Butter Sauce	8940-01-152-6821	5.50	7.6	0.19	18
Green Beans	8915-01-150-2861	7.99	5.0	0.19	25
Apple Dessert	8940-01-147-7855	4.96	7.0	0.19	25

* Product costs based on limited commercial buys

Nutritional Data Base. To determine nutritional intake profiles when modelling the effects of varying the number of portions per tray, the nutritional data base was developed. Nutritional values were taken from actual product analysis where available. However, for some items, the United States Department of Agriculture's Handbook Number 8 of nutritional values was used to determine the product nutritional values.¹ Table 2 presents a summary for some of this data.

TABLE 2: Nutrition Data Base Example

ITEM	NSN	H2O g	PROT g	FAT g	CA mg	P mg	FE mg	NA mg	K mg	Mg mg	VIT A I.U.	C mg	B1 mg	B2 mg	NIAC mg	B6 mg	CARBO g	KCAL	GRAMS/ SERVING
1 BEEF STEW	8940-01-009-7993	193.	32.	7.	22.	200.	4.9	512.	522.	47.	2670.	0.	.1	.3	5.	.1	14.	250.	250.
2 BEEF IN BARBECUE SAUCE	8940-01-010-0881	107.	29.	10.	36.	231.	4.3	554.	618.	41.	900.	7.	.0	.2	6.	.1	15.	269.	164.
3 BEEF STRIPS W/GR PEPPERS	8940-01-123-2191	125.	29.	5.	12.	265.	4.0	434.	498.	34.	0.	0.	.0	.0	.2	.3	6.	183.	167.
4 HAM SLICES	8905-01-143-3326	56.	20.	5.	53.	144.	.9	640.	150.	13.	0.	0.	.2	.1	4.	.1	1.	125.	93.
5 SPICED CAKE	8920-01-144-0565	25.	3.	5.	21.	44.	.9	174.	66.	0.	111.	0.	.1	.0	1.	.0	41.	223.	67.
6 SLICED PEACHES	8915-01-143-3327	131.	1.	0.	7.	19.	.4	3.	215.	0.	708.	6.	.0	.0	1.	.0	33.	138.	119.
7 FRANKFURTERS IN BRINE	8905-01-124-8628	80.	15.	22.	10.	101.	1.8	1145.	150.	12.	0.	0.	.0	.1	2.	.1	1.	258.	99.
8 ESCALLOPED POTATOES	8940-01-147-6362	140.	4.	1.	23.	41.	.8	352.	148.	16.	50.	3.	.0	.0	1.	.1	17.	95.	164.
9 BEANS WITH BACON SAUCE	8915-01-147-7853	108.	11.	6.	136.	190.	2.4	513.	521.	69.	0.	0.	.1	.1	1.	.1	33.	228.	160.
10 APPLE DESSERT	8940-01-147-7855	104.	0.	2.	7.	10.	1.1	126.	85.	4.	0.	0.	.0	.0	0.	.0	44.	196.	109.
11 SLICED PEARS	8915-01-093-9489	133.	0.	0.	8.	11.	.3	1.	140.	0.	0.	1.	.0	.0	0.	.0	33.	135.	120.
12 APPLESAUCE	8915-01-091-3083	129.	0.	0.	7.	8.	.8	3.	111.	0.	69.	1.	.0	.0	0.	.0	41.	165.	123.
13 CHERRY NUT CAKE	8920-01-144-0563	29.	8.	29.	101.	161.	2.9	448.	153.	37.	0.	0.	.1	.2	2.	.0	90.	657.	143.
14 ORANGE NUT CAKE	8920-01-144-0564	28.	7.	24.	141.	162.	2.6	483.	137.	33.	0.	0.	.1	.1	2.	.0	94.	622.	143.
15 GREEN BEANS	8915-01-150-2861	928.	1.	0.	37.	18.	.8	282.	69.	11.	472.	4.	.0	.0	0.	.0	5.	25.	72.
16 ROAST BEEF W/MUSHROOMS	8940-01-150-2857	124.	29.	6.	11.	444.	3.4	844.	474.	33.	0.	0.	.1	.3	4.	.2	3.	188.	154.
17 CANADIAN BACON	8905-01-151-2480	68.	14.	8.	6.	148.	1.0	984.	90.	13.	0.	0.	.1	.1	1.	.0	0.	253.	147.
18 ROAST CHICKEN WITH GRAVY	8940-01-153-8540	119.	30.	13.	141.	368.	1.6	733.	376.	33.	0.	0.	.0	.2	8.	.2	1.	241.	150.
19 MACARONI AND CHEESE	8940-01-150-2860	121.	11.	7.	162.	182.	2.0	780.	55.	15.	240.	0.	.1	.3	1.	.0	25.	210.	167.
20 CREAM GROUND BEEF	8940-01-151-5845	189.	31.	20.	23.	266.	4.0	1100.	450.	30.	0.	0.	.1	.3	6.	.1	10.	340.	253.

Force Data Base. TSA provided force structures for representative Army Divisions. This information included the number of units within that division, strength levels by unit, and the number of Mobile Kitchen Trailers (MKT) allocated per division by unit. For the Light Infantry Divisions (LID), the number of Kitchens, Company Level Field Feeding (KCLFF) issued by unit was also provided (Tables 3 and 4).

Data Base Operations. An overview of the types of information calculated using the three data bases is contained in Figure 2.

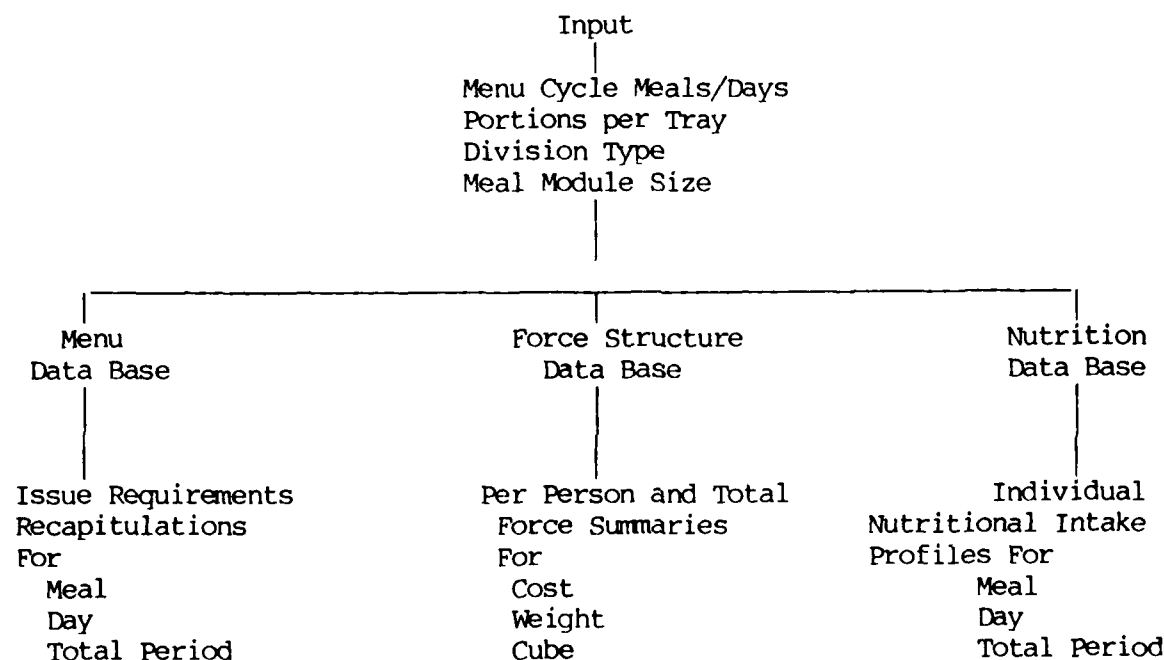


Figure 2: Unitization Flow Chart

o Menu. The 14 day breakfast and dinner menu for the Combat Field Feeding System-Field Feeding Concept-Force Development Test and Experimentation (CFFS-FFC-FDTE) provided by TSA was used as the baseline menu (Appendix A).

o Portions Per Tray. To determine portions per tray alternatives, computer programs were developed to allow analysis of alternative meal module sizes for various force structures and Class I issue points. While many portion alternatives were analyzed, the discussions that follow will focus upon those considered most practical (Table 5).

TABLE 3: Armor Division Field Feeding Support *

UNIT	STRENGTH	TOTAL		
		# UNITS	STRENGTH	MKTs
HHC DIV	599	1	599	2
INF BDE				
HHC	91	1	91	1
INF BN	844	4	3376	16
DIVARTY				
HHC/TAB	282	1	282	1
FAB(MLRs)	131	1	131	1
FA BN(155)	458	3	1374	6
FA BN(155)	730	1	730	3
ENG BN				
HHC	234	1	234	1
ENG CO	164	4	656	4
SIGN BN	682	1	682	2
ARM BDE				
HHC	91	2	182	2
TK BN	552	6	3312	12
SPT CMD	1074	1	1074	4
TAM	415	1	415	2
FWDSPt BN(2x4)	437	2	874	4
MI BN	314	1	314	1
ADA BN	626	1	626	4
CA BDE				
ATK HEL BN	264	1	264	1
CBT SPT AVN BN	378	1	378	2
AIRCav SQDN,HHT	236	1	236	1
AIRCav TRP	193	2	386	2
TOTAL			16216	72

* January 1985

TABLE 4: Light Infantry Division Field Feeding Support *

UNIT	STRENGTH	TOTAL			
		# UNITS	STRENGTH	MKT	KCLFF
HHC DIV	914	1	914	4	7
INF BDE					
HHC BDE	77	3	231	3	3
INF BN	570	9	5130	18	36
FA BNS	415	3	1245	6	12
FWDSUPCO, DISCOM	465	2	930	4	10
FWDSUPCO, DISCOM	335	1	335	2	5
HHT/RECON SQD	315	1	315	2	5
HHC CA BDE	677	1	677	3	5
HHC, DISCOM	248	1	248	1	2
HHCSUPCO, S&T BN, DISCOM	624	1	624	3	5
TOTAL			10649	46	90

* January 1985

TABLE 5: Portions per Tray Terminology

PORTION ALTERNATIVE	DESCRIPTION
STANDARD	THE NUMBER OF PORTIONS PER TRAY PACK AS GIVEN IN THE SPECIFICATION DOCUMENT. THE NUMBER OF PORTIONS RANGES FROM 12 TO 25 DEPENDING ON THE ITEM.
NOMINAL	THE NUMBER OF PORTIONS PER TRAY PACK IS DEFINED TO EQUAL COMPARABLE A & B RATION PORTION YIELDS.
12/18/24	THE NUMBER OF PORTIONS PER TRAY PACK IS ESTABLISHED AT 12 FOR PRODUCTS WITH SPECIFICATIONS OF LESS THAN 18 PORTIONS PER TRAY. THE NUMBER OF PORTIONS PER TRAY PACK IS ESTABLISHED AT 18 FOR PRODUCTS WITH SPECIFICATIONS BETWEEN 18 AND 24 PORTIONS PER TRAY. THE NUMBER OF PORTIONS PER TRAY PACK IS ESTABLISHED AT 24 FOR PRODUCTS WITH SPECIFICATIONS OF 25 PORTIONS PER TRAY.
12/18	THE NUMBER OF PORTIONS PER TRAY PACK IS ESTABLISHED AT 12 FOR PRODUCTS WITH SPECIFICATIONS OF LESS THAN 18 PORTIONS PER TRAY. THE NUMBER OF PORTIONS PER TRAY PACK IS ESTABLISHED AT 18 FOR ALL OTHER PRODUCTS.
12	THE NUMBER OF PORTIONS PER TRAY PACK IS ESTABLISHED AT 12 FOR ALL PRODUCTS.
18	THE NUMBER OF PORTIONS PER TRAY PACK IS ESTABLISHED AT 18 FOR ALL PRODUCTS.

EXAMPLE:

FOOD ITEM	PORTION ALTERNATIVE	
	STANDARD	12/18
Peaches	25	18
Cream Ground Beef	12	12
White Rice	18	18
Eggs and Ham	20	18

o Nutrition. By varying the the number of portions per tray in the menu data base, calculations could be performed on the nutrition data base to determine the effects on the nutritional intake profiles per meal per day and for the entire 14 day period. Table 6 presents an example of the results obtained using the first two days of the menu cycle when the number of portions per tray were established at 12/18. Daily totals for nutrition are compared to the Recommended Daily Allowances established in AR 40-25.² An in-depth review of nutritional issues affecting final selection will be discussed in the results section.

o Excess, Overissue and Base Factors. A meal module was defined as the number of Tray Packs, condiments and disposables required to subsist a given number of troops for a specific meal. While an optimal size meal module can be determined, there will always be some inefficiency in the size specified due to the varying unit strength levels. Excess, overissue and base factors have been identified to explain the effect of this inefficiency. Excess represents the difference between the actual number of portions of Tray Pack foods provided in a meal module and the meal module size specified. The following example details that relationship.

Meal Module Size	= 45
Mixed Vegetables Portions Per Tray	= 25
Trays Required For Meal Module	= 2
Excess Portions	= (25x2)-45 = 5

Overissue represents the difference between the actual number of portions of Tray Pack foods provided in the meal modules and the force supported. An example of this relationship follows:

Meal Module Size	= 45
Force To Be Subsisted	= 77
Meal Modules Required	= 2
Overissue Portions	= (45x2)-77 = 13

Base represents the exact cost, weight, or volume for the meal module after subtracting the inefficiency amounts due to excess and overissue.

Programs were developed to calculate the base, overissue, and excess cost, weight and volume for any force structure and alternative meal module size. Although cost is used for the following example, weight and volume were calculated in the same manner (Table 7). Table 8 provides an example of the results of excess and overissue analyses for a range of meal module sizes being issued to the LID for the entire 14-day CFFS-FFC-FDTE menu cycle using the 12/18 portion alternative.

TABLE 6: Nutritional Intake Profile Example

MENU ANALYSIS

DATE: 25 March 86

SERVING SIZE: 12/18

DAY: 1

MEALS: BREAKFAST & DINNER

ITEM	NSN	H2O	PROT	FAT	Ca	P	Fe	Na	K	Mg	Vit A	C	B1	B2	NIAC	B6	CARBO	KCAL	GRAMS/ SERVINGS
		g	g	g	mg	mg	mg	mg	mg	mg	I.U.	mg	mg	mg	mg	mg	g		
BREAKFAST																			
FRUIT COCKTAIL	8915-01-150-2855	133.	0.	0.	14.	18.	.6	1.	224.	0.	750.	3.	.0	.0	1.	.0	32.	133.	167.
BREAD	8940-01-009-7993	27.	7.	2.	64.	73.	.5	33.	79.	0.	0.	0.	.0	.1	1.	.0	38.	201.	76.
MILK		198.	8.	8.	268.	211.	.0	113.	327.	0.	320.	2.	.0	.3	0.	.0	11.	148.	227.
PEANUT BUTTER	8940-01-009-7993	0.	12.	22.	28.	160.	.7	205.	258.	70.	1400.	23.	.8	.0	5.	.1	6.	275.	43.
JELLY	3940-01-009-7993	10.	0.	0.	2.	3.	.1	13.	11.	2.	10.	1.	.0	.0	0.	.0	18.	75.	28.
GRAPE JUICE		1.	1.	0.	18.	23.	.7	30.	199.	13.	0.	9.	.0	.0	0.	.0	47.	194.	50.
COFFEE	8940-01-009-7993	0.	0.	0.	4.	10.	.2	2.	81.	8.	0.	15.	.1	.0	1.	.0	2.	9.	3.
SUBTOTAL		370.	28.	33.	398.	498.	2.8	747.	1179.	93.	2480.	53.	.9	.4	8.	.1	156.	1035.	
DINNER																			
SLICED PEARS	8915-01-093-9489	133.	0.	0.	8.	11.	.3	1.	140.	0.	0.	1.	.0	.0	0.	.0	33.	135.	167.
BREAD	8940-01-009-7993	27.	7.	2.	64.	73.	.5	383.	79.	0.	0.	0.	.0	.1	1.	.0	38.	201.	76.
MILK		198.	8.	8.	268.	211.	.0	113.	327.	0.	320.	2.	.0	.3	0.	.0	11.	148.	227.
PEANUT BUTTER	8940-01-009-7993	0.	12.	22.	28.	160.	.7	205.	258.	70.	1400.	23.	.8	.0	5.	.1	6.	275.	43.
JELLY	8940-01-009-7993	10.	0.	0.	2.	3.	.1	13.	11.	2.	10.	1.	.0	.0	0.	.0	18.	75.	28.
BEVERAGE BSE		0.	0.	0.	0.	0.	.0	0.	0.	0.	0.	26.	.0	.0	0.	.0	38.	150.	38.
COFFEE	8940-01-009-7993	0.	0.	0.	4.	10.	.2	2.	81.	8.	0.	15.	.1	.0	1.	.0	2.	9.	3.
SUBTOTAL		368.	27.	33.	374.	468.	1.8	717.	896.	80.	1730.	68.	.9	.4	7.	.1	146.	993.	
TOTAL		738.	56.	66.	772.	966.	4.5	1465.	2075.	173.	4210.	121.	1.8	.8	16.	.2	302.	2028.	
% OF RDA		49.	56.	41.	97.	121.	25.	21.	111.	43.	84.	202.	82.	44.	65.	9.	76.	56.	
RDA		1500.	100.	160.	800.	800.	18.	7000.	1875.	400.	5000.	60.	2.2	1.8	24.	2.2	400.	3600.	

TABLE 6: Nutritional Intake Profile Example (Cont)

MENU ANALYSIS

DATE: 25 March 86

SERVING SIZE: 12/18

DAY:

MEALS: BREAKFAST & DINNER

ITEM	MSN	H2O	PROT	FAT	Ca	P	Fe	Na	K	Mg	Vit A	C	B1	B2	NIAC	B6	CARBO	KCAL	GRAMS/ SERVINGS
		g	g	g	mg	mg	mg	mg	mg	mg	I.U.	mg	mg	mg	mg	mg	g		
BREAKFAST																			
APPLE COFFEE CAKE	8920-01-151-6922	147.	3.	6.	23.	13.	.9	180.	82.	0.	89.	1.	.1	.0	1.	.0	56.	282.	83.
SLICED PEARS	8915-01-093-9489	133.	0.	0.	8.	11.	.3	1.	140.	0.	0.	1.	.0	.0	0.	.0	33.	135.	167.
BREAD	8940-01-009-7993	27.	7.	2.	64.	73.	.5	383.	79.	0.	0.	0.	.0	.1	1.	.0	38.	77.	74.
MILK		198.	8.	8.	268.	211.	.0	113.	327.	0.	320.	2.	.0	.3	0.	.0	11.	148.	227.
PEANUT BUTTER	8940-01-009-7993	0.	12.	22.	28.	160.	.7	205.	258.	70.	1400.	23.	.8	.0	5.	.1	6.	275.	43.
JELLY	8940-01-009-7993	10.	0.	0.	2.	3.	.1	13.	11.	2.	10.	1.	.0	.0	0.	.0	18.	75.	28.
ORANGE JUICE		0.	1.	0.	0.	29.	.4	2.	380.	0.	370.	79.	.1	.0	1.	.0	20.	86.	22.
COFFEE	8940-01-009-7993	0.	0.	0.	4.	10.	.2	2.	81.	8.	0.	15.	.1	.0	1.	.0	2.	9.	3.
SUBTOTAL		515.	32.	39.	398.	510.	3.1	899.	1359.	80.	2189.	123.	1.1	.4	8.	.1	184.	1211.	
DINNER																			
CHERRY DESSERT	8940-01-152-5507	110.	1.	2.	0.	14.	18.1	3.	89.	144.	167.	0.	.0	.0	0.	.0	46.	201.	158.
SLICED PEACHES	8915-01-143-3327	131.	1.	0.	7.	19.	.4	3.	215.	0.	708.	6.	.0	.0	1.	.0	33.	138.	165.
BREAD	8940-01-009-7993	27.	7.	2.	64.	73.	.5	383.	79.	0.	0.	0.	.0	.1	1.	.0	38.	201.	76.
MILK		198.	8.	8.	268.	211.	.0	113.	327.	0.	320.	2.	.0	.3	0.	.0	11.	148.	227.
PEANUT BUTTER	8940-01-009-7993	0.	12.	22.	28.	160.	.7	205.	258.	70.	1400.	23.	.8	.0	5.	.1	6.	275.	43.
JELLY	8940-01-009-7993	10.	0.	0.	2.	3.	.1	13.	11.	2.	10.	1.	.0	.0	0.	.0	18.	75.	28.
BEVERAGE BSE		0.	0.	0.	0.	0.	.0	0.	0.	0.	0.	26.	.0	.0	0.	.0	38.	150.	38.
COFFEE	8940-01-009-7993	0.	0.	0.	4.	10.	.2	2.	81.	8.	0.	15.	.1	.0	1.	.0	2.	9.	3.
SUBTOTAL		476.	29.	34.	373.	490.	20.0	721.	1060.	224.	2605.	73.	.9	.4	8.	.1	193.	1197.	
TOTAL		991.	61.	73.	771.	1001.	23.0	1621.	2419.	304.	4794.	195.	2.0	.8	17.	.2	377.	2408.	
% OF RDA		66.	61.	46.	96.	125.	128.	23.	129.	76.	96.	325.	91.	44.	69.	9.	94.	67.	
RDA		1500.	100.	160.	800.	800.	18.	7000.	1875.	400.	5000.	60.	2.2	1.8	24.	2.2	400.	3600.	

TABLE 6: Nutritional Intake Profile Example (Cont)

MENU ANALYSIS SUMMARY FOR CFEES TEST

DATE: 25 March 86

SERVING SIZE: 12/18

DAY: 1 - 2

MEAL: BREAKFAST & DINNER

TOTAL	H2O	PROT	FAT	Ca	P	Fe	Na	K	Mg	Vit A	C	B1	B2	NIAC	B6	CARBO	KCAL
1	738.	56.	66.	772.	966.	4.5	1465.	2075.	173.	4210.	121.	1.8	.8	16.	.2	302.	2028.
2	991.	61.	73.	771.	1001.	23.0	1621.	2419.	304.	4794.	195.	2.0	.8	17.	.2	377.	2408.
MEAN	864.	58.	69.	772.	983.	13.8	1543.	2247.	239.	4502.	158.	1.9	.8	16.	.2	339.	2218.

TABLE 7: Example of Tray Pack Unitization Program Calculations

Issuing a Meal Module (MM)

Meal Module Size = 45

	Portions per Tray	Cost per Tray (\$)	Trays per MM	Cost per MM (\$)	Excess per MM	
					Portions	Cost (\$)
Mixed						
Vegetables	25	7.20	2	14.40	5	1.45

Sample Calculations:

Number of Trays per MM = $45/25 = 1.8$ = 2
 Cost per MM = 7.20×2 = \$14.40
 Excess Portions = $(25 \times 2) - 45 = 5$
 Portion Cost = $7.20/25$ = \$0.29
 Excess Cost = 5×0.29 = \$1.45

Issuing to a Force

Number of persons = 77
 Meal Module Size = 45

Number of MKTs	Strength	Number of MMs	Cost for Force (\$)			
			Excess	Overissue	Base	Total
1	77	2	2.90	3.77	22.13	28.80

Sample Calculations:

Number of MMs = $77/45 = 1.71$ = 2
 Excess Cost = 2×1.45 = \$2.90
 Overissue = $(45 \times 2) - 77 = 13$
 Overissue Cost = 13×0.29 = \$3.77
 Total Cost = 14.40×2 = \$28.80
 Base Cost = $28.80 - 2.90 - 3.77 = \$22.13$

TABLE 8: Base, Overissue and Excess Factors for a Range of Meal Module Sizes

TRAY PACK INITIALIZATION PROGRAM

DATE: 5 JUNE 86
 FORCE: LID
 FORCE STRENGTH = 10649.
 ISSUE TO: MKTs
 SERVING SIZE: 12/18
 MENU: 1 - 14
 MEAL: BREAKFAST & DINNER
 BASE COST = 536658.
 BASE WEIGHT = 451543.
 BASE CUBE = 13386.

MEAL MODULE	COST			WEIGHT			CUBE			TOTAL # MEAL	
	DUE TO EXCESS (\$)	DUE TO OVERISSUE (\$)	COST/ MEAL/ TOTAL (\$)	DUE TO EXCESS (lb)	DUE TO OVERISSUE (lb)	WT./ MEAL/ TOTAL (lb)	DUE TO EXCESS (cuft)	DUE TO OVERISSUE (cuft)	CUBE/ MEAL/ TOTAL (cuft)		
31	93266.	41390.	671513.	2.25	34812.	564799.	1.9	2326.	1032.	16744.	10360.
Z	17.4	7.7	125.1	17.4	7.7	125.1	17.4	7.7	7.7	125.1	
32	70579.	27778.	635215.	2.13	23364.	534270.	1.8	1760.	693.	15839.	9800.
Z	13.1	5.2	118.3	13.1	5.2	118.3	13.1	5.2	5.2	118.3	
33	52330.	38768.	627955.	2.11	32607.	528164.	1.8	1395.	967.	15658.	9688.
Z	9.7	7.2	117.0	9.7	7.2	117.0	9.7	7.2	7.2	117.0	
34	34080.	42499.	613436.	2.06	28664.	515952.	1.7	850.	1060.	15296.	9464.
Z	6.3	7.9	114.3	6.3	7.9	114.3	6.3	7.9	7.9	114.3	
35	16586.	43658.	597102.	2.00	13950.	502213.	1.7	414.	1089.	14889.	9212.
Z	3.1	8.1	111.2	3.1	8.1	111.2	3.1	8.1	8.1	111.2	
36	0.	25761.	562619.	1.89	0.	473210.	1.6	0.	642.	14029.	8680.
Z	.0	4.8	104.8	.0	4.8	104.8	.0	4.8	4.8	104.8	
37	251220.	41390.	829467.	2.78	213146.	609501.	2.3	6335.	1032.	20753.	8680.
Z	46.8	7.7	154.5	47.2	7.7	154.9	47.2	7.7	7.7	155.0	
38	234071.	53187.	804116.	2.76	198711.	64988.	2.3	5907.	1326.	20619.	8624.
Z	43.6	9.9	153.5	44.0	9.9	153.9	44.1	9.9	9.9	154.0	
39	210770.	47057.	794823.	2.67	170021.	670167.	2.2	5322.	1174.	19883.	9316.
Z	39.2	6.8	140.0	39.6	6.8	140.4	39.8	6.8	6.8	140.5	

Both overissue and excess factors with regard to cost demonstrate distinct trends. As a function of force structure, the overissue percentage above the base cost increases as the meal module size increases. Issuing an additional meal module to a force that is only slightly larger than a multiple of the specified meal module size results in a high overissue factor (Figure 3). The percentage excess cost above the base cost decreases as meal module sizes become larger due to the greater packaging efficiency achieved (Figure 4). Figure 5 displays that the union of these two percentages results in a minimum point being achieved at a meal module size of 36. Figure 6 graphically presents the relationship among cost, weight, and volume. These variables trend in the same manner and will be minimized at the same point. It should be noted that each of these variables operates in a discrete fashion.

o Menu Recapitulation. Programs were developed that calculated Tray Pack issue requirements per meal, per day, and for the entire 14-day period. Calculations were straightforward. An example of the menu recapitulation output using the first four days of the CFFS-FFC-FDTE menu is provided in Table 9.

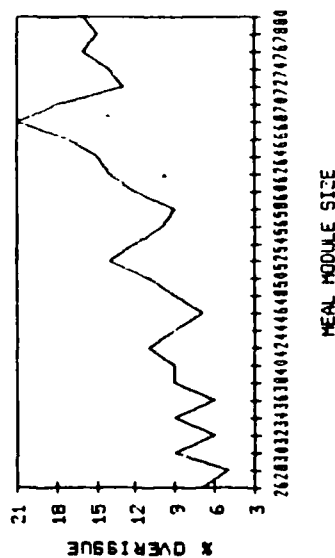


Figure 3. Distribution of Overissue Costs for Meal Modules at 12/18 Portions per Tray

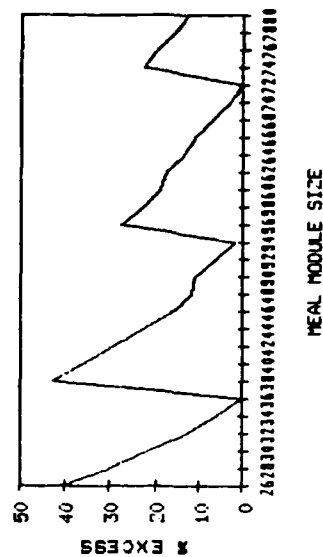


Figure 4. Distribution of Excess Costs for Meal Modules at 12/18 Portions per Tray

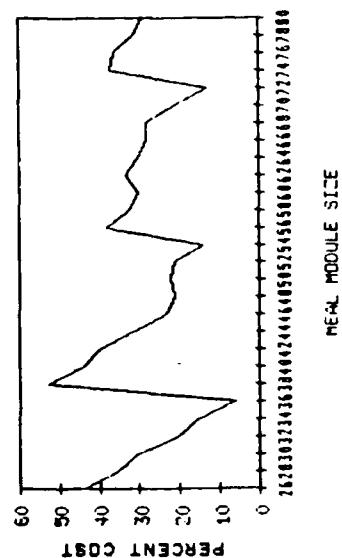


Figure 5. Distribution of Percent Overissue Plus Excess Costs for Meal Modules at 12/18 Portions per Tray

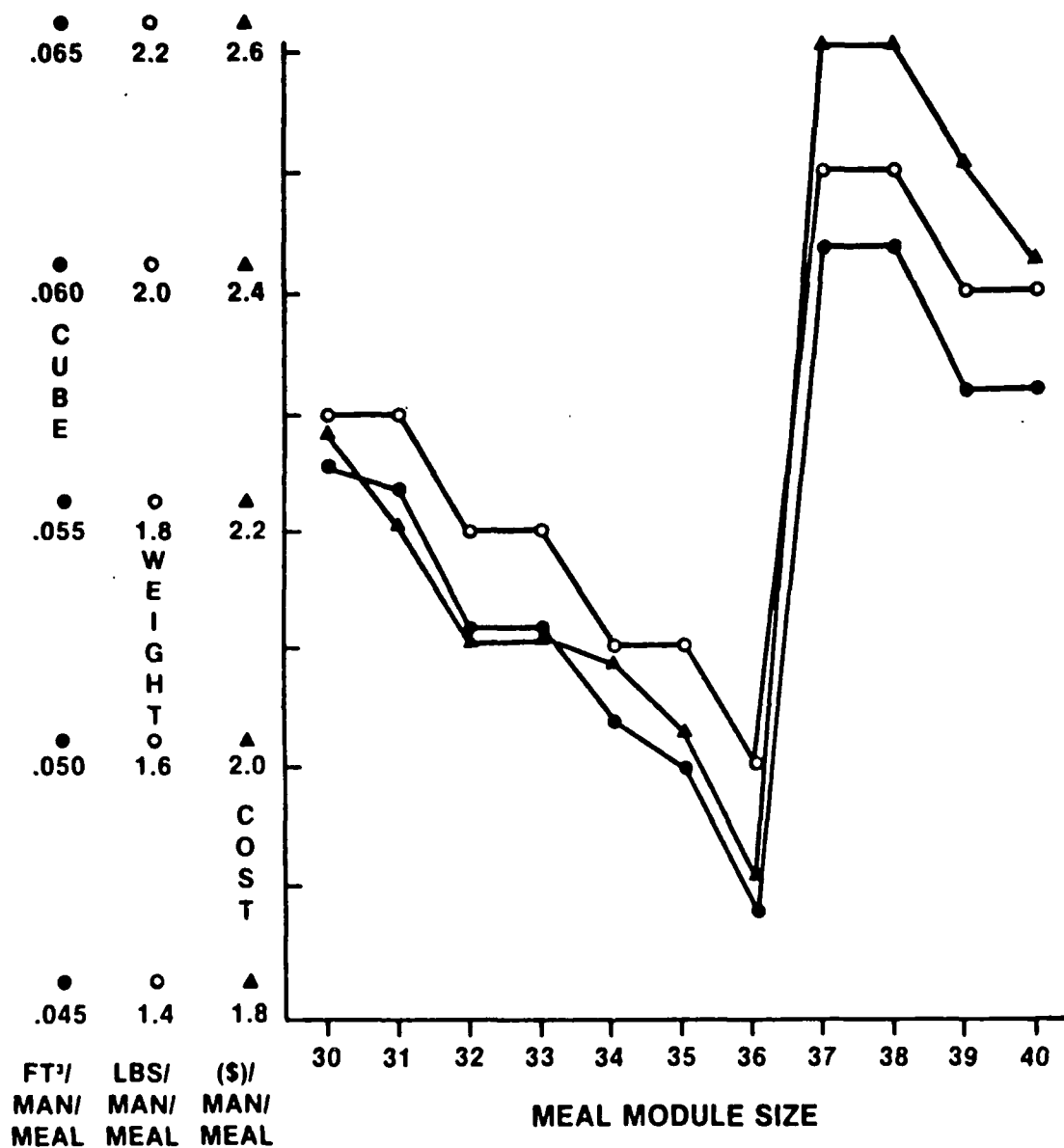


Figure 6. Meal Module Trends for Cost, Cube, and Weight

TABLE 9: Recapitulation of Menu Issues (TSA Form 40)

TRAY PACK INITIALIZATION PROGRAM

DATE: 21 JULY 86

PORTION SIZE: 12/18

DAY: 1 - 4

MEAL: BREAKFAST & DINNER

MEAL MODULE: 36

FORCE: ARMORED DIV.

ISSUE TO: MKT

FORCE STRENGTH 16679

NO. OF MM REQUIRED PER MEAL: 491

NOTE: * = #10 CAN

RECAPITULATION OF MENU ISSUES (TSA FORM 40)

ITEM	MEAL	1	2	3	4	MEAL	TOTAL GRAND	UNIT PRICE	TOTAL PRICE
BEEF STEW	B	0	1473	0	0	1473	1473	8.5	12520.
BEEF IN BARBECUE SAUCE	D	982	0	0	0	982	982	12.1	11882.
HAM SLICES	B	0	0	982	0	982	982	17.2	16890.
SPICE CAKE	B	0	0	0	982	982	982	6.7	6579.
SLICED PEACHES *	D	0	982	0	0	982	1964	2.8	5499.
BEANS WITH BACON SAUCE	D	0	0	0	0	982	982	5.9	5794.
APPLE DESSERT	B	0	982	982	0	1964	0		
	D	0	982	0	0	982	2946	4.9	14435.
SLICED PEARS *	B	0	0	0	982	982	0		
	D	982	0	0	0	982	1964	2.9	5696.
GREEN BEANS	D	0	982	0	0	982	982	7.9	7758.
CREAM GROUND BEEF	B	1473	0	0	0	1473	2946	9.3	27398.
PORK SAUSAGE LINKS	B	982	0	0	0	982	982	10.2	10016.
FRUIT COCKTAIL *	B	0	982	0	0	982	0		
	D	0	0	982	0	982	1964	3.7	7267.
BUTTERED NOODLES	B	0	0	982	0	982	982	5.3	5205.
POTATO SALAD	D	982	0	0	0	982	982	7.1	6972.
MIXED VEGETABLES	B	0	982	0	0	982	0		
	D	0	0	0	982	982	1964	7.1	13944.
DICED POTATOES IN BUTTER	B	982	0	0	0	982	1964	0	
	D	0	0	982	0	982	2946	5.5	16203.
PEAS AND MUSHROOMS	D	982	0	982	0	1964	1964	7.3	14337.
DICED PINEAPPLE *	B	982	0	982	0	1964	1964	4.0	7856.
PORK SLICES W/GRAVY	D	0	0	982	982	1964	1964	19.0	37316.
LASAGNA W/GRAVY	D	0	1473	0	0	1473	1473	8.0	11784.

COLUMN TOTALS

33388.

245353.

TABLE 9: Recapitulation of Menu Issues (TSA Form 40) (Cont)

TRAY PACK UNITIZATION PROGRAM

DATE: 21 JULY 86

PORTION SIZE: 12/18

DAY: 1 - 4

MEAL: BREAKFAST & DINNER

MEAL MODULE: 36

FORCE: LID

ISSUE TO: MKT

FORCE STRENGTH 10649

NO. OF MM REQUIRED PER MEAL: 310

NOTE: * = #10 CAN

RECAPITULATION OF MENU ISSUES (TSA FORM 40)

ITEM	MEAL	1	2	3	4	TOTAL MEAL	UNIT PRICE	TOTAL PRICE
BEEF STEW	B	0	930	0	0	930	8.5	7905.
BEEF IN BARBECUE SAUCE	D	620	0	0	0	620	12.1	7502.
HAM SLICES	B	0	0	620	0	620	17.2	10664.
SPICE CAKE	B	0	0	0	620	620	6.7	4154.
SLICED PEACHES *	D	0	620	0	620	1240	2.8	3472.
BEANS WITH BACON SAUCE	D	0	0	0	620	620	5.9	3658.
APPLE DESSERT	B	0	620	620	0	1240		
	D	0	620	0	0	620	4.9	9114.
SLICED PEARS *	B	0	0	0	620	620		
	D	620	0	0	0	620	2.9	3596.
GREEN BEANS	D	0	620	0	0	620	7.9	4898.
CREAM GROUND BEEF	B	930	0	0	930	1860	9.3	17298.
PORK SAUSAGE LINKS	B	620	0	0	0	620	10.2	6324.
FRUIT COCKTAIL *	B	0	620	0	0	620		
	D	0	0	620	0	620	3.7	4588.
BUTTERED NOODLES	B	0	0	620	0	620	5.3	3286.
POTATO SALAD	D	620	0	0	0	620	7.1	4402.
MIXED VEGETABLES	B	0	620	0	0	620		
	D	0	0	0	620	620	7.1	8804.
DICED POTATOES IN BUTTER	B	620	0	0	620	1240		
	D	0	0	620	0	620	5.5	10230.
PEAS AND MUSHROOMS	D	620	0	620	0	1240	7.3	9052.
DICED PINEAPPLE *	B	620	0	620	0	1240	4.0	4960.
PORK SLICES W/GRAVY	D	0	0	620	620	1240	19.0	23560.
LASAGNA W/GRAVY	D	0	930	0	0	930	8.0	7440.
COLUMN TOTALS						21080.		154907.

Section III

ANALYSIS OF RESULTS

INTRODUCTION

Selection of an optimal meal module size required several analyses to determine whether the identified alternatives would meet the guidance provided at the outset of the project. Although some of the guidelines and parameters appeared independent, they were in fact highly interdependent. For example, determination of the number of portions per tray upon which to standardize was contingent upon the the number of soldiers to be fed from a meal module. Nutrition was directly related to the number of portions per tray. Topics presented in this section focus upon the guidelines as noted below.

- a. Utilize the 14 day menu of the Combat Field Feeding System-Field Feeding Concept-Field Development Test and Experimentation (CFFS-FFC-FDTE).
- b. Maintain nutritional standards.
- c. Minimize the average cost per man per meal over the CFFS-FFC-FDTE menu.
- d. Minimize the weight and cube of a meal module.
- e. The meal module size selected must:
 - (1) satisfy both Light Infantry and Armor Divisional requirements.
 - (2) be optimized for the Mobile Kitchen Trailer.
 - (3) be capable of being on/offloaded by one MOS 94 BRAVO.

PORTIONS PER TRAY

The unitization Tray Pack data base program allowed for the analysis of portion alternatives in combination with the capacity to model Class I issue procedures to any divisional unit of representative Light and Armor Divisions. Analyses indicated six practical options for standardizing the number of portions per Tray Pack. The six portions alternatives as defined in Table 5 included STANDARD, NOMINAL, 12/18/24, 12/18, 12, and 18 portions per tray.

MEAL MODULE SIZE

Figure 6 graphically depicted the relationship among the average per man meal cost, weight and volume associated with meal module size. These variables exhibited similar trends and all were minimized at the same point. Minimization of the average meal cost per man was selected as the primary discriminating factor among alternatives.

Representative Light and Armor Divisions were analyzed to model the divisional extremes that the selected meal module would have to satisfy. The Class I issue point that was the focus of these analyses was the Mobile Kitchen Trailer (MKT). The MKT is the major food preparation asset for battalion mess sections. Two MKTs are authorized per battalion and may be operated independently or in a consolidated mode. Additional analyses were conducted using the Kitchen, Company Level Field Feeding (KCLFF) as a Class I issue point. In the Light Divisions, the KCLFF will be deployed to prepare one hot meal daily for company size units.

Cost figures presented in these analyses reflect the cost of providing Tray Packs only. Condiments, beverages, and disposable eating and servingware were to be packaged according to the specific meal module size selected after the number of portions per tray had been chosen. Therefore, the cost associated with the issue of these items would be a constant and would not affect the selection of the optimal meal module size.

A meal module to subsist 36 was determined to be the best size from a cost minimization standpoint. The 12/18 portion alternative was selected as the best option. The 12/18 alternative provided the minimum average meal cost per man of \$1.89 for a Light Infantry Division and \$1.91 for the Armor Division at a meal module size of 36. Analysis of the Light Infantry Division feeding with the KCLFF determined that a meal module size of 36 also provided the minimum average meal cost per man of \$1.95. Tables 10 and 11 summarize the best meal module sizes for Light and Armor Divisions from a minimum cost per man per meal basis for a variety of portion alternatives.

Although the 12/18/24 portion alternative resulted in the same minimum cost as the 12/18 option, this alternative was not selected, as the 12/18 option satisfied the established guidelines.

A meal module size of 36 with the number of portions per tray established at 18 for all products provided the minimum average cost per meal per man of \$1.79 for both Light and Armor Divisions. This alternative was not selected for further development because it reduces the portion quantity of many entrees below that of comparable A and B rations, which may have had an adverse effect on nutritional intake potential. Discussion of nutrition results will be presented in the next section.

The STANDARD portion alternative was not selected because of existing requisition and distribution difficulties noted in the statement of need for unitized rations. The STANDARD portion alternative minimum meal cost per man (\$1.87) was achieved at a meal module size of 72. Another reason for not selecting this alternative was that a meal module size of 72 would weigh over 150 pounds, thus exceeding the weight limitations for on/offloading by one individual.

TABLE 10. Minimum Cost per Man per Meal for
the Light Infantry and Armor Divisions *

	PORTION ALTERNATIVE	MEAL MODULE SIZE	AVERAGE COST PER PERSON PER MEAL (\$)
LIGHT INFANTRY			
ISSUING TO MKT	18**	36	1.79
	STANDARD	72	1.87
	12/18/24	36	1.89
	12/18	36	1.89
	NOMINAL	72	2.00
	12	24	2.64
ARMOR DIVISION			
ISSUING TO MKT	18**	36	1.81
	STANDARD	36	1.91
	12/18/24	36	1.91
	12/18	36	1.91
	NOMINAL	72	2.04
	12	24	2.68

* CFFS-FFC-FDTE 14-Day Menu

** Reduces Portion Sizes

TABLE 11. Minimum Cost per Man per Meal for the Light Infantry Division
Issuing to the KCLFF*

PORTION ALTERNATIVE	MEAL MODULE SIZE	AVERAGE COST PER PERSON PER MEAL (\$)
18**	36	1.85
STANDARD	36	1.95
12/18/24	36	1.95
12/18	36	1.95
NOMINAL	72	2.15
12	24	2.75

* CFFS-FFC-FDTE 14-Day Menu

** Reduces Portion Sizes

The NOMINAL portion alternative was not chosen. The minimum cost per person per meal for the NOMINAL alternative exceeded \$2.00 for both Light and Armor Divisions and was over 5% higher than the cost for the 12/18 portion alternative.

The portion alternative that established all Tray Pack products at 12 portions per tray was the most costly for both the Light and Armor Divisions. The lowest cost per person per meal for this alternative was achieved at a meal module size of 24. For both the Light and Armor Divisions, selection of this option would require an additional \$0.75 per person per meal for unitization.

NUTRITIONAL IMPACT

Prior to selecting the alternative upon which to standardize the number of portions per tray, all alternatives were evaluated for nutritional considerations by Office of The Surgeon General (OTSG) personnel attached to the U.S. Army Institute of Environmental Medicine (USARIEM). With the exception of the 18 portions per tray alternative, which reduced many entree portion quantities, all portion alternatives were determined to be nutritionally adequate. Table 12 provides a nutritional comparison of the selected 12/18 portion alternative with the STANDARD portion alternative. The 12/18 portion alternative provides increased potential for nutritional intakes of necessary vitamins and minerals over the STANDARD portion alternative.

WEIGHT AND VOLUME CONSIDERATIONS

Table 13 presents a comparison of the weight, number of trays, and volume associated with portion alternatives at a meal module size of 36. Because of menu cycle, the number of Tray Packs vary. With the exception of the 12 portions per tray alternative, the difference between portion alternatives is insignificant for the range and mean number of trays, weight, and volume. The weight for a meal module size of 36 including condiments for the 12/18 portion alternative is about 96 pounds evenly distributed between two containers.

3

In accordance with MIL-STD-1472C, Notice 2, 10 May 84, the maximum weight that can be lifted to a height of 5 feet by a male is about 56 pounds. If the height to be lifted is reduced to 3 feet, the maximum weight increases to 87 pounds (Figure 7). However, the upper limit for lifting for MOS 94 Bravo is 50 pounds. Therefore, using the 50-pound limit as a maximum, a meal module to subsist 36 conforms to these tolerances as packaged in two containers.

MEAL MODULE DESIGN

Evaluations of container design alternatives were conducted to investigate packaging and pack requirements for the meal module and the final pallet load. Prototype meal modules and pallet loads were designed and fabricated. These prototypes underwent drop, vibration, and

TABLE 12. Nutritional Comparison of Selected Alternative with
Standard Portions per Tray *

	12/18		STANDARD	
	MEAN	%RDA	MEAN	%RDA
PROTEIN	88	88	82	82
FAT**	56	35	52	33
CALCIUM	433	54	385	48
PHOSPHORUS	1219	152	1108	138
IRON	11.7	65	10.8	60
SODIUM**	3811	54	3571	51
POTASSIUM**	1855	99	1684	90
MAGNESIUM	123	31	114	29
VITAMIN A	8325	167	6887	138
VITAMIN C	26	43	22	37
VITAMIN B1	0.9	41	0.8	36
VITAMIN B2	1.1	61	1.0	56
NIACIN	16	67	15	63
VITAMIN B6	0.3	14	0.3	14
CARBOHYDRATE	197	49	168	42
CALORIES	1651	46	1481	41

* Per Person Average Over CFFS-FFC-FDTE MENU

** MAXIMUM VALUES USED AS REFERENCE

TABLE 13. A Comparison of the Average Weight and Number of Trays for Various Portion Sizes

Meal Module Size = 36

	TRAYS		WEIGHT		VOLUME
	RANGE -----	MEAN -----	RANGE -----	MEAN -----	CU FT -----
BREAKFAST					
Portion Alternative -----					
18	8-10	8	59-75	63	1.5
12/18	8-10	9	57-75	68	1.7
12/18/24	8-10	9	57-74	68	1.7
STANDARD	8-10	9	59-75	70	1.7
Nominal	8-11	10	57-85	74	1.9
12	12-15	13	88-112	94	2.4
DINNER					
Portion Alternative -----					
18	8-10	8	50-70	55	1.5
12/18	8-10	8	50-70	59	1.5
12/18/24	8-10	9	51-70	58	1.7
STANDARD	8-10	9	53-69	58	1.7
NOMINAL	8-11	10	54-80	64	1.9
12	12-15	12	75-105	87	2.2

NOTE: Condiments/Disposables add about 30 lb and 1.4 cu ft

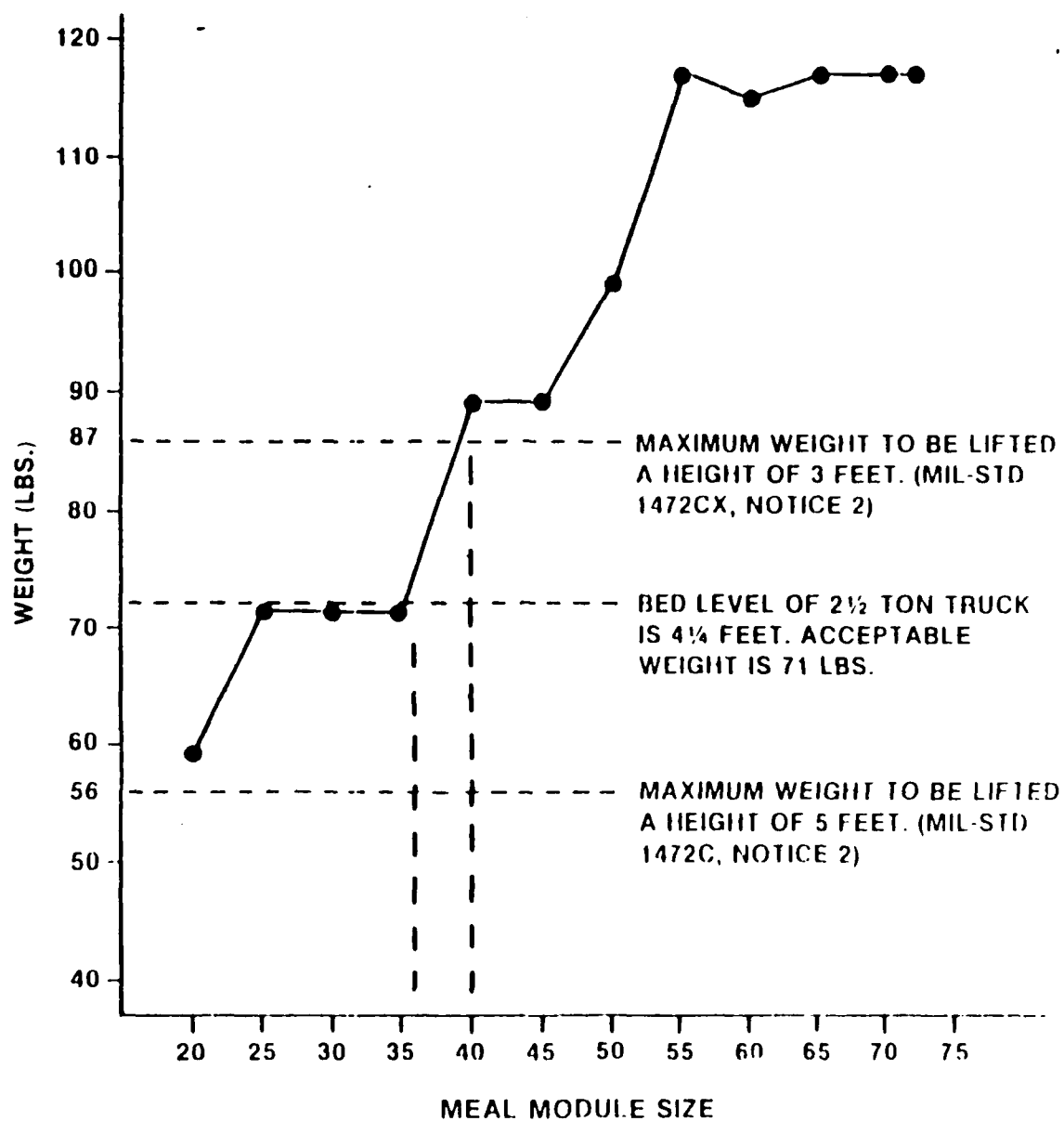


Figure 7. Individual Weight Lift Limits for Single Meal Modules

compression rough handling tests. Results of these tests led to the final determination of fiberboard and nonfiberboard packaging and internal support bracing and blocking packing requirements. A detailed discussion of the performance testing for the meal module and final pallet load is provided in Appendix B. Results of airdrop testing are discussed in Appendix C. Airdrop rigging procedures are found in Appendices D and E.

Two identical V3C, RSC-L fiberboard containers with inner liners comprise the meal module. Each container has dimensions of 23.75"(L) x 13.00"(W) x 8.75"(H). When the individual containers are strapped together to form the meal module, the meal modules dimensions become 23.75"(H) X 13.00"(W) x 17.50"(H).

Figure 8 presents the pallet load configuration for the designed meal modules. Twelve meal modules comprise a pallet load. The pallet load is protected from weather by shrink-wrapped polyvinylchloride. Tables 14 and 15 provide a summary for the meal module and pallet load weight and volume. The designed module utilizes about 96% of the maximum allowable MILVAN volume while only requiring about 45% of the weight allowable.

Figures 9 (Box 1) and 10 (Box 2) detail the basic distribution of items within the two containers. Each box weighs about 48 pounds, thus conforming to the 50-pound on/offloading limit for MOS 94 Bravo. Box 1 components include Tray Packs, disposable dining sets, and compartmented mess trays. Box 2 consists primarily of Tray Packs, condiments and beverage mixes. When the menu includes #10 cans of fruit, one can is included in each box of the meal module. The number of Tray Packs and the type of condiments and beverage mixes vary as a function of the menu.

CONCLUSION

Natick has completed analyses to determine an optimal meal module size to support the new Light Divisions and other restructured divisions of the Army of Excellence. This new meal concept is termed the Meal Module, Tray Pack, 36-Persons and consists of Tray Packs, other food items, condiments, and disposable eatingware to subsist 36 persons for a specific meal.

In December 1985, the Army DCSLOG requested that the Defense Logistics Agency, Defense Personnel Support Center, TSA, and Natick expedite efforts to have the meal module fielded early in calendar year 1986. With the support of many individuals in different agencies and Commands, milestone schedules were moved up to meet DCSLOG's request. In February 1986, all assembly documentation for the meal module was forwarded to DPSC. Requisitioning and delivery of the Meal Module, Tray Pack, 36-Persons to designated user units started in April 1986.

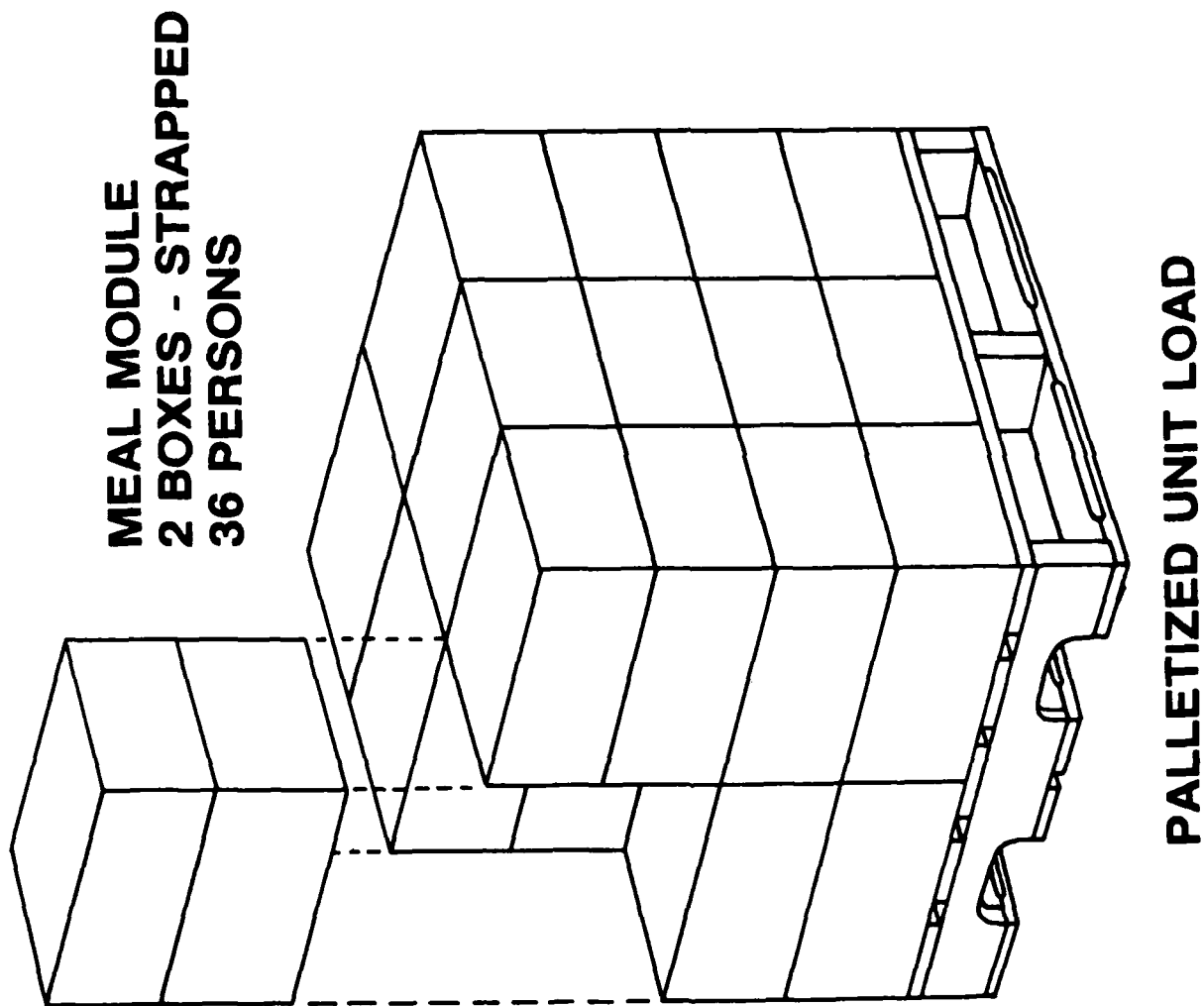


Figure 8. Meal Module, Tray Pack, 36-Persons, Palletized Unit Load

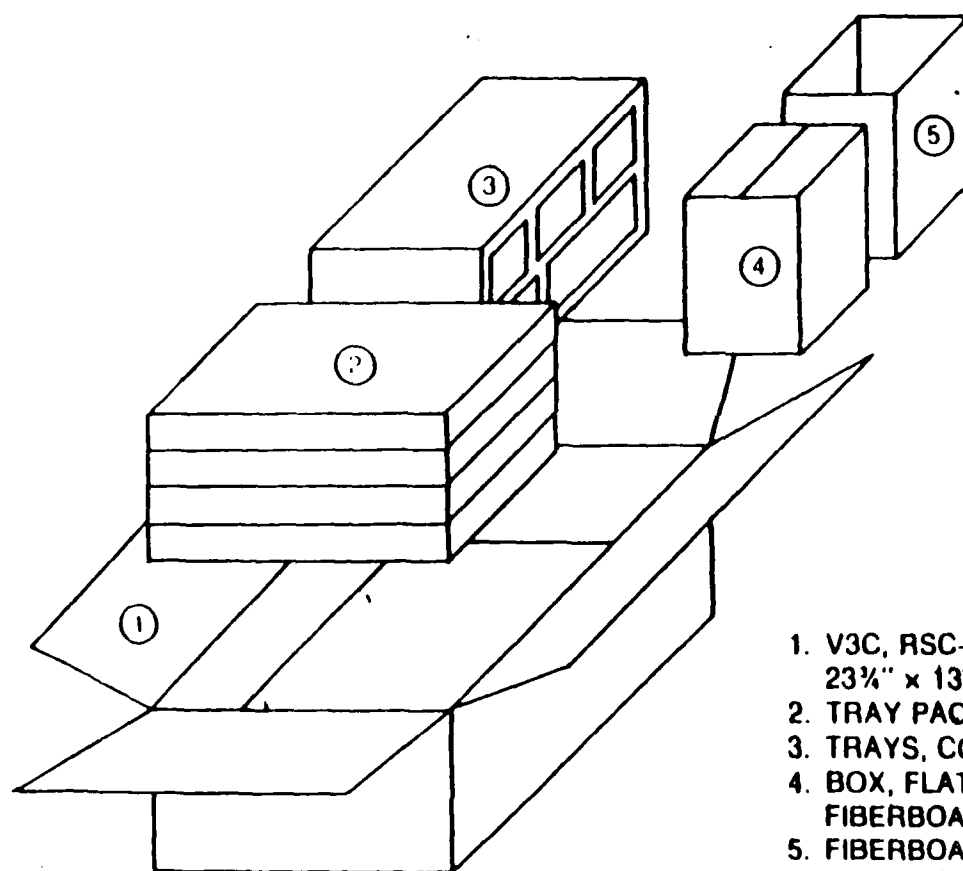
TABLE 14. Meal Module, Tray Pack, 36-Persons
Summary of Weight and Volume

	Weight		Per Person Average (LB)	Volume	
	Module Range (LB)	Average (LB)		Module CU FT	Per Person CU FT
Breakfast	91-98	96	2.7	3.1	.09
Dinner	88-96	90	2.5	3.1	.09

TABLE 15. Meal Module, Tray Pack 36-Persons
Dimensional Data

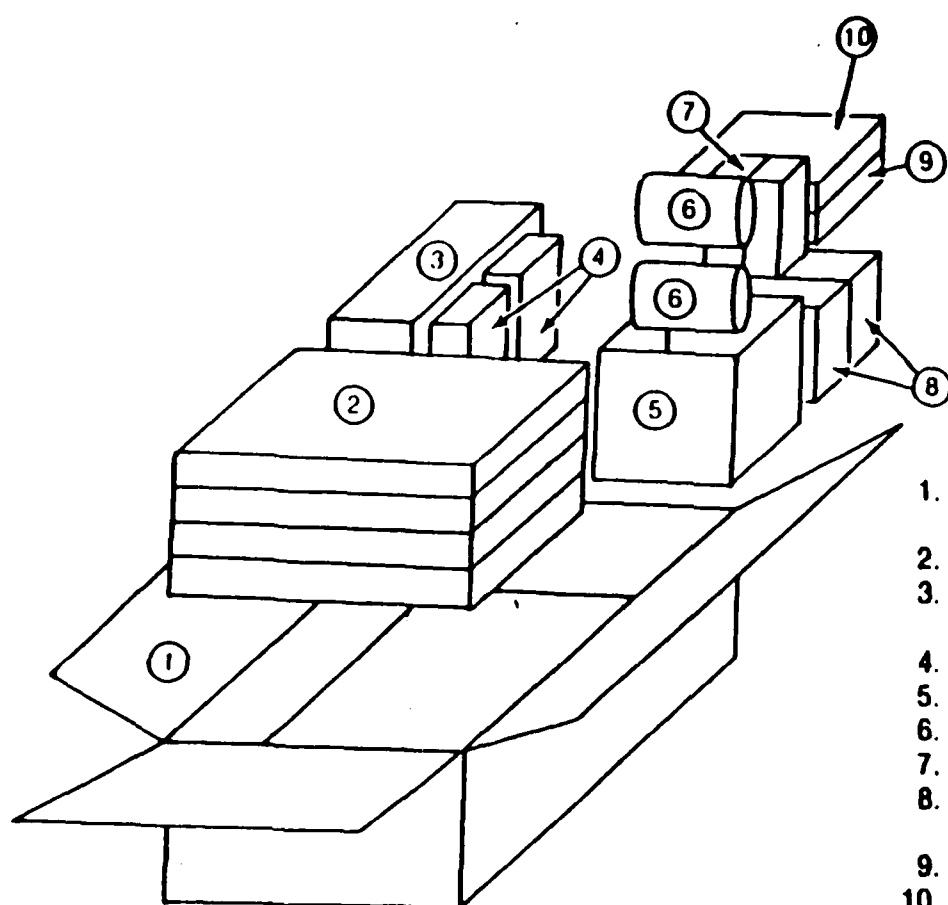
	Pallet Maximums	Per Meal Module	12 Meal Modules Per Pallet	Utilization Per Pallet (%)
Cu FT	46	3.1	44	96
Weight (LB)	2500	96.0	1225	45
Width (IN)	40	13.0	39	97
Height (IN)	41	17.5	41	100
Length (IN)	48	23.8	48	99

includes a pallet 6" high, 50 LBS



1. V3C, RSC-L FIBERBOARD BOX
23 $\frac{3}{4}$ " x 13" x 8 $\frac{1}{2}$ "
2. TRAY PACKS W/FIBERBOARD PADS
3. TRAYS, COMPARTMENTED MESS
4. BOX, FLATWARE V3C, RSC,
FIBERBOARD 6 $\frac{1}{2}$ " x 6 $\frac{1}{2}$ " x 8 $\frac{1}{16}$ "
5. FIBERBOARD AIR CELL C-1
(HOLDS No 10 CAN OR OTHER
COMPONENTS)

Figure 9. Meal Module, Tray Pack, 36-Persons, Box 1 of 2



1. V3C FIBERBOARD BOX RSC-L
23 1/2" x 13" x 8 1/2"
2. TRAY PACKS W/FIBERBOARD PADS
3. FIBERBOARD AIR CELL C-3
W/CUPS
4. BOXES OF JELLY PACKETS
5. FIBERBOARD AIR CELL C-1
6. TWO NO 2 1/2 CANS
7. CUSHIONED HOT SAUCE
8. BOXES OF PEANUT BUTTER
PACKETS
9. BOX OF COFFEE PACKETS
10. BOX OF CREAMER PACKETS

Figure 10. Meal Module, Tray Pack, 36-Persons, Box 2 of 2

LIST OF REFERENCES

1. "Composition of Foods Raw, Processed, Prepared," Agricultural Handbook Number 8, United States Department of Agriculture, Washington, D.C., October 1975.
2. Departments of the Army, the Navy, and the Air Force. Army Regulation 40-25, BUMED Instruction 10110.3E, and Air Force Regulation 160-95. Medical Services Nutritional Standards, Washington, D.C., Department of the Army, the Navy, and the Air Force, 30 August 1976.
3. MIL-STD-1472C, "Human Engineering Design Criteria for Military Systems, Equipment and Facilities", Department of Defense, 2 May 1981.
4. Annual Book of ASTM Standards, Part 15, ASTM D999-75, American Society for Testing and Materials, Philadelphia, PA, 1986
5. FED STD 101, Method 5008, "Preservation, Packaging, and Packing Materials: Test Procedures", General Services Administration, January 1969
6. Annual Book of ASTM Standards, Part 15, ASTM D642-47, American Society for Testing and Materials, Philadelphia, PA, 1986

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-87/045 in the series of reports approved for publication.

APPENDIX A

BASELINE MENU

TABLE A-1: 14 -DAY TRAY PACK MENU

Breakfast 1

National Stock Number

Pineapple w/Syrup	8915-00-170-5127
Eggs/Ham	8940-01-151-4184
Canadian Bacon	8905-01-151-2488
Escalloped Potatoes	8940-01-147-6362
Grape Juice, Instant	8915-01-010-1471
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 2

Fruit Cocktail w/Syrup	8915-00-286-5482
Beef Stew	8940-01-009-7993
Mixed Vegetables	8915-01-173-2858
Chocolate Pudding	8940-01-159-1569
Orange, Juice, Instant	8915-00-530-3414
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 3

Pineapple w/Syrup	8915-00-170-5127
Chicken ala King	8940-01-154-3525
Buttered Noodles	8940-01-151-5844
Apple Dessert	8940-01-147-7855
Grape, Juice, Instant	8915-01-010-1471
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 4

Pears w/Syrup	8915-00-616-0223
Creamed Geound Beef	8940-01-151-5845
Potatoes w/ Butter Sauce	8940-01-152-6821
Blueberry Cake	8920-01-166-3576
Orange, Juice, Instant	8915-00-530-3414
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 5

Pineapple w/Syrup	8915-00-170-5127
Ham Slices	8905-01-143-3326
Sweet Potatoes, Glazed	8940-01-153-0710
Cherry Dessert	8915-01-010-1471
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

TABLE A-1: 14-Day Tray Pack Menu (cont'd)

Breakfast 6

Peaches w/Syrup	8915-00-577-4203
Eggs/Ham	8940-01-151-4184
Pork Sausage Links	8905-01-151-6920
Escalloped Potatoes	8940-01-147-6362
Orange, Juic, Instant	8915-00-530-3414
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 7

Pineapple w/Syrup	8915-00-170-5127
Beef Stew	8940-01-009-7993
Green Beans	8915-01-150-2861
Blueberry Dessert	8940-01-151-5463
Grape Juice, Instant	8915-01-010-1471
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 8

Peaches w/Syrup	8915-00-577-4203
Chicken ala King	8940-01-154-3525
Potatoes w/Butter Sauce	8940-01-152-6821
Apple Dessert	8940-01-147-7855
Orange Juice, Instant	8915-00-530-3414
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 9

Pears w/ Syrup	8915-00-616-0223
Canadian Bacon	8905-01-151-2488
Sweet Potatoes, Glazed	8940-01-153-0710
Cherry Dessert	8940-01-152-5507
Grape Juice, Instant	8915-01-010-1471
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 10

Fruit Cocktail w/Syrup	8915-00-286-5482
Eggs/Ham	8940-01-151-4184
Pork Sausage Links	8905-01-151-6920
Potatoes w/Butter Sauce	8940-01-152-6821
Orange Juice, Instant	8915-00-530-3414
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

TABLE A-1: 14 Day Tray Pack Menu (cont'd)

Breakfast 11

Pineapple w/Syrup	8915-00-170-5127
Chicken ala King	8940-01-154-3525
Buttered NMoodles	8940-01-151-5844
Apple Dessert	8940-01-147-7855
Grape Juice, Instant	8915-01-010-1471
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 12

Fruit Cocktail w/Syrup	8915-00-286-5482
Creamed Ground Beef	8940-01-151-5842
Potatoes w/Butter Sauce	8940-01-152-6821
Cherry Dessert	8940-01-152-5507
Orange Juice, Instant	8915-00-530-3414
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Breakfast 13

Pineapple w/Syrup	8915-00-170-5127
Beef Stew	8940-01-009-7993
Green Beans	8915-01-150-2861
Blueberry Dessert	8940-01-151-5463
Grape Juice, Instant	8915-01-010-1471
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listsed

Breakfast 14

Fruitcocktail w/Syrup	8915-00-286-5482
Ham Slices	8905-01-143-3326
Escalloped Potatoes	8940-01-147-6362
Cherry Dessert	8940-01-152-5507
Orange Juice, Instant	8915-00-530-3414
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Table A-1: 14-Day Tray Pack Menu (cont'd)

Dinner 1

Meatloaf w/Mushroom Gravy	8940-01-151-6919
Potatoe Salad	8940-01-162-2178
Peas and Mushrooms	8915-01-157-2281
Pears w/Syrup	8915-00-616-0223
Beverage Base, Powder, Lemon-Lime (ind)	8960-00-404-6063
Disposable Unit (Table A-2)	as listed
Condiments	as listed

Dinner 2

Lasagna w/Meat Sauce	8940-01-124-4544
Green Beans	8915-01-150-2861
Spice Cake	8920-01-144-0565
Peaches w/Syrup	8915-00-577-4203
Beverage Base, Powder, Grape (ind)	8960-00-404-6061
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 3

Sliced Pork w/Gravy	8940-01-010-4843
Escalloped Potatoes	8940-01-147-6362
Peas and Mushrooms	8915-01-157-2281
Fruit Cocktail w/Syrup	8915-00-286-5482
Beverage Base, Powder, Orange (inf)	8960-00-404-6064
Disposable unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 4

Frankfurters in Brine	8905-01-124-8628
Beans w/Pork	8915-01-147-7853
Mixed Vegetables	8915-01-173-2858
Peaches w/Syrup	8915-00-577-4203
Beverage Base, Powder, Lemon-Lime (ind)	8960-00-404-6063
Disposable (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 5

Beef Strips w/Green Peppers	8940-01-123-2191
Buttered Noodles	8940-01-151-5844
Whole Kernel Corn	8915-01-151-6908
Apple Dessert	8940-01-147-7855
Beverage Base, Powder, Lemon-Lime (ind)	8960-00-404-6063
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

TABLE A-1: 14 Day Tray Pack Menu (cont'd)

Dinner 6

Lasagna w/Meat	8940-01-124-4544
Green Beans	8915-01-150-2861
Applesauce	8915-00-127-8272
Spice Cake	8920-01-144-0565
Beverage Base, Powder, Grape (ind)	8960-00-404-6061
Disposables (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 7

Chicken w/Gravy	8940-01-153-8540
Buttered Noodles	8940-01-151-5844
Carrots, Sliced	8915-01-151-6914
Pears w/Sauce	8915-00-616-0223
Beverage Base, Powder, Orange (ind)	8960-00-404-6064
Disposable Units (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 8

Beef w/Barbecue Sauce	8940-01-010-0881
Buttered Noodles	8940-01-151-5844
Peas and Mushrooms	8915-01-157-2281
Chocolate Pudding	8940-01-159-1569
Beverage Base, Powdered, Lemon-Lime (ind)	8960-00-404-6063
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 9

Roast Beef w/Mushroom Gravy	8940-01-150-2857
Escalloped Potatoes	8940-01-147-6362
Carrots, Sliced	8915-01-151-6914
Peaches w/Syrup	8915-00-577-4203
Beverage Base, Powdered, Lemon (ind)	8960-00-404-6062
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 10

Beef w/Barbecue Sauce	8940-01-010-0881
Macaroni and Cheese	8940-01-150-22860
Mixed Vegetables	8915-01-173-2858
Applesauce	8915-00-127-8272
Beverage Base, Powdered, Grape (ind)	8960-00-404-6061
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

TABLE A-1: 14-Day Tray Pack Menu (cont'd)

Dinner 11

Meatloaf w/Mushroom Gravy	8940-01-151-6919
Potatoes w/Butter Sauce	8940-01-151-6821
Whole Kernal Corn	8915-01-151-6908
Peaches w/Syrup	8915-00-577-4203
Beverage Base, Powder, Orange (ind)	8960-00-404-6064
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 12

Beef Strips w/Green Peppers	8940-01-123-2191
Macaroni and Cheese	8940-01-150-2860
Mixed Vegetables	8915-01-173-2858
Applesauce	8915-01-127-8272
Beverage Base, Powder, Lemon-Lime (ind)	8960-00-404-6063
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 13

Turkey Slices w/Gravy	8940-01-143-3328
Sweet Potatoes, Glazed	8940-01-153-0710
Whole Kernel Corn	8915-01-151-6908
Chocolate Pudding	8940-01-159-1569
Beverage Base, Powder, Orange (ind)	8960-00-404-6064
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

Dinner 14

Roast Beef w/Mushroom Gravy	8940-01-150-2857
Buttered Noodles	8940-01-151-5844
Applesauce	8915-00-127-8272
Spice Cake	8920-01-144-0565
Beverage Base, Powder, Grape (ind)	8960-00-404-6061
Disposable Unit (Table A-2)	as listed
Condiments (Table A-3)	as listed

TABLE A-2: DISPOSABLE UNIT

Items included with Meal Module, Tray Pack, 36-Persons:

ITEM

1. Accessory Dining Pack - 36 Each

Each pack individually wrapped containing the items below:

ITEM	NATIONAL STOCK NUMBER
Plastic Fork, Heavy Duty, 1 each	7340-00-022-1315
Plastic Knife, Heavy Duty, 1 each	7340-00-022-1316
Plastic Knife, Heavy Duty, 1 each	7340-00-022-1317
Napkin, table, paper, 1 each	8540-00-276-7669
Sugar, refined, 1 each	8925-00-205-3144
Salt, Table, 1 each	8950-01-008-7560
Pepper, Black, ground, 1 each	8950-01-079-4568

2. Paper tray 5-compartment, NSN 7350-01-012-8787, 36 each.
3. Cups, hot/cold drink, molded cardboard, 8 oz. NSN 7350-00-988-6498, 36 each.
4. Bag, waste receptable, black polyethylene (5-mil), NSN 8105-00-989-2376, 3 each.

TABLE A-3. CONDIMENTS

Items included with Meal Module, Tray Pack, 36-person.

ITEM	NATIONAL STOCK NUMBER	UNIT ISSUE
Coffee, Instant, Ind	8955-00-170-9318	36 pg
Cream Substitute, Ind	8940-00-782-3161	36 pg
Hot Sauce	8950-01-074-4918	2 bottles
Jelly, Grape, Ind	8930-00-149-1058	36 pg
(Sub) Jelly, Grape		
Can	8930-00-543-7607	1 #2 1/2 can
or		
Jelly, Apple, Ind	8930-00-149-1056	36 pg
(Sub) Jelly, Apple		
Can	8930-00-260-7637	1 #2 1/2 can
Peanut Butter, Ind	8930-00-149-1054	36 pg
(Sub) Peanut Butter,		
Can	8930-00-543-7602	1 #2 1/2 can

NOTE: These recommended National Stock Numbers are deemed minimum acceptable quality and are provided as a guide.

APPENDIX B

Performance Testing of Palletized Meal Module, Tray Pack, 36-Persons

APPENDIX B

Performance Testing of Palletized Meal Module, Tray Pack, 36-Persons

A meal module consists of T ration, beverages, condiments and disposables required to subsist 36-persons for a specific meal. A meal module is comprised of two identical V3C, RSC-L fiberboard boxes with inner pads and cells. The components in box 1 are standard for all 14 Breakfast menus and 14 dinner menus. The components in the second box vary with each menu. Figures B-1 through B-8 detail the assembly of components for all menus.

Preparation

Twelve meal modules were fabricated in the 6 tray dinner style (figures B-1 and B-5). The product in the Tray Packs was frankfurters in brine. The #10 cans all contained blueberry pie filling. Coffee, creamer, beverage mix, jelly, and peanut butter packets were Meal, Ready-to-Eat components.

Two nylon straps were used to hold together the two cartons comprising each module. The strapping was located approximately eight inches equidistant from each end. The pallet was assembled with 2 x 3 modules per tier x 2 tiers. External protection for the pallet load was provided through use of shrink-wrapped polyvinylchloride. The total size of the pallet load including the pallet was 40" x 48" x 43". The total weight of the pallet load was approximately 1200 lbs.

4

VIBRATION TESTING OF SHIPPING CONTAINERS (ASTM D999-75)

After placing the pallet load on a vibration table, the vibration frequency was set so that the pallet load would leave the table momentarily at some interval during the cycle. While the table is in motion, one should be able to insert a 1/16-inch-thick- piece of material between the bottom edge of the pallet and the table. The resulting frequency was approximately 240 RPM. After 30 minutes, the pallet load was turned 180 degrees and vibrated for and additional 30 minutes. Results of vibration tests indicated some movement of the nylon straps holding the two containers together. An additional strap placed lengthwise around the containers will prevent movement due to vibration.

DROP TEST (FED STD 101, METHOD 5008)

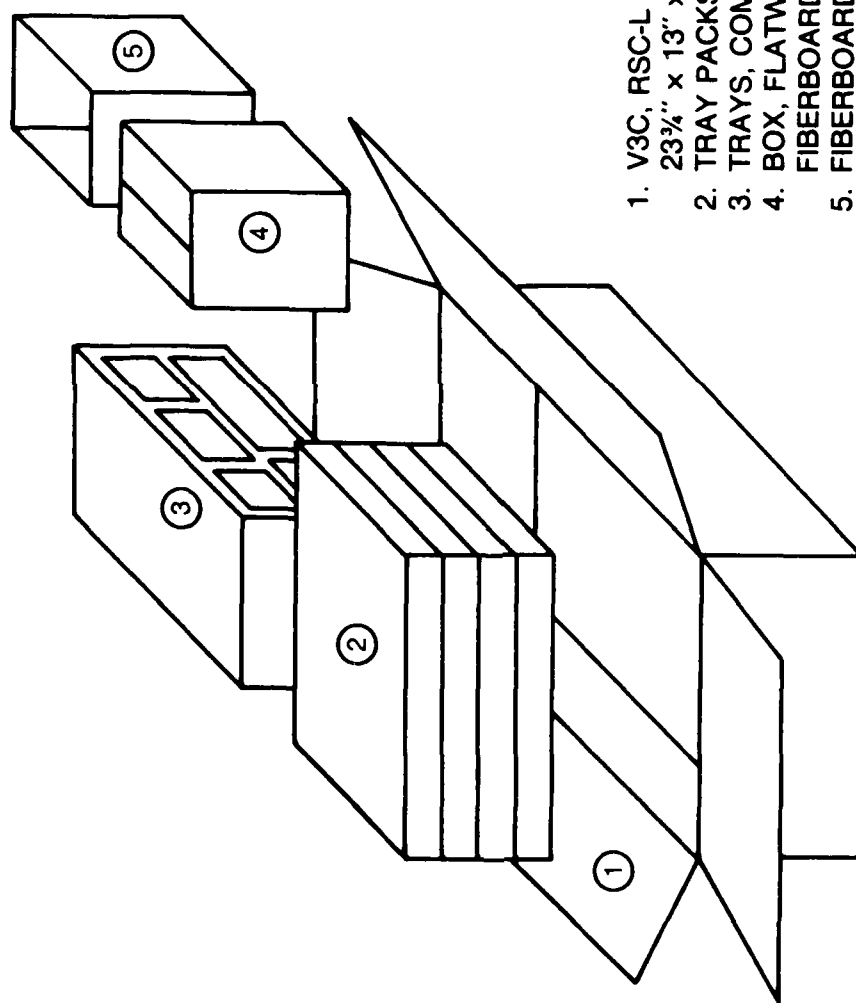
The pallet load was placed on a concrete surface in a normal manner. One end of the base of the pallet was raised and supported on a sill nominally 6 inches high. The unsupported end of the load was then raised 12 inches high and allowed to fall freely to the concrete surface. This was performed twice each on 2 opposite edges. Results of drop testing indicated that only minor damage occurred. Two Tray Packs, one #10 can and the rims of the top cup in each stack of paper cups sustained damage. Upon detailed inspection of the damaged products, it was determined that the failures in the Tray Pack and the #10 can were the result of weaknesses present prior to the drop testing. Therefore, the only component that required further protection was the paper cups and this will be accomplished through the addition of cushioning material.

COMPRESSION TEST FOR SHIPPING CONTAINERS (ASTM D642-47)

This test was performed on a Tinius Olson Compression Tester to measure the compression strength of the pallet load. A pallet was placed on the top of the load and placed on the bottom platen of the testing machine. The top platen was lowered and a maximum load of 8800 lb. was gradually applied to the load. The deflection was measured at 1/4 inch. This indicates that this pallet load can withstand the maximum stacking height of 4 pallets high while in storage, without concern of collapsing.

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 1 OF 2

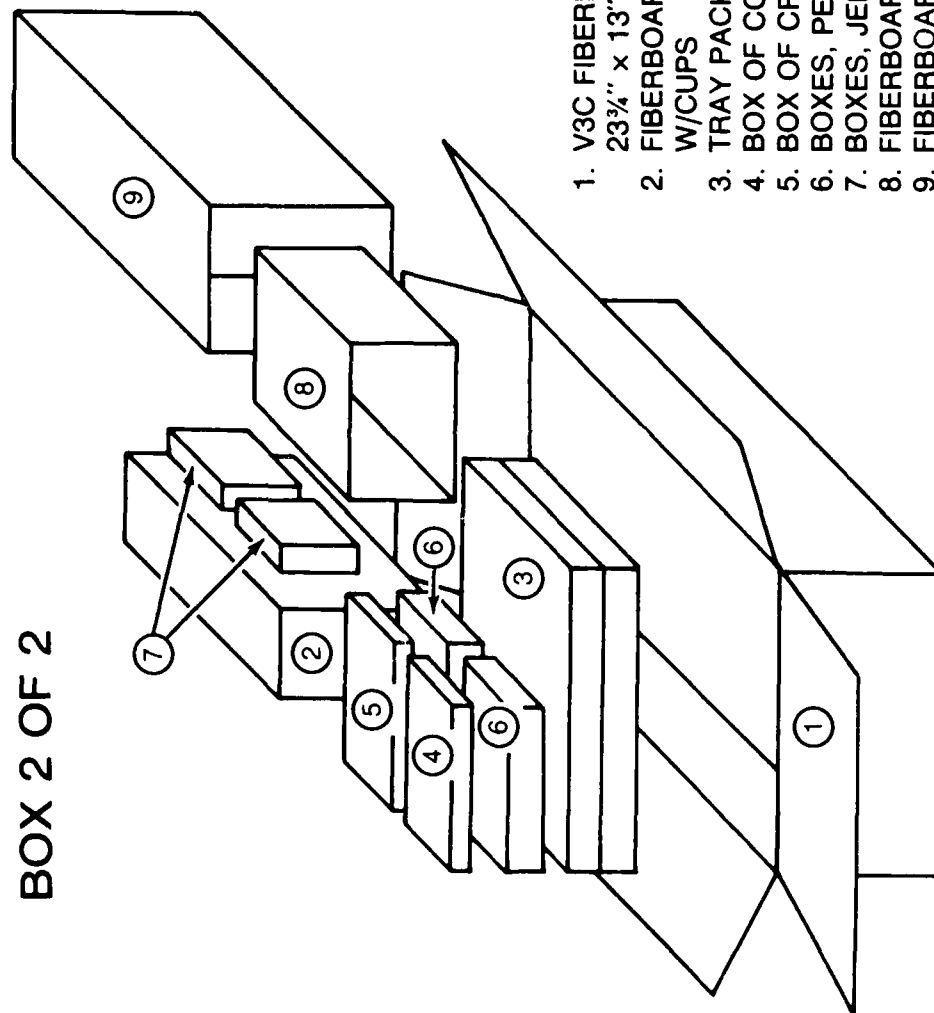


1. V3C, RSC-L FIBERBOARD BOX
23 $\frac{3}{4}$ " x 13" x 8 $\frac{3}{4}$ "
2. TRAY PACKS W/FIBERBOARD PADS
3. TRAYS, COMPARTMENTED MESS
4. BOX, FLATWARE V3C, RSC,
FIBERBOARD 6 $\frac{3}{4}$ " x 6 $\frac{1}{2}$ " x 8 $\frac{5}{16}$ "
5. FIBERBOARD AIR CELL C-1
(HOLDS NO 10 CAN OR OTHER
COMPONENTS)

Figure B-1. Meal Module, Tray Pack, 36-Persons, Standard Container

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 2 OF 2



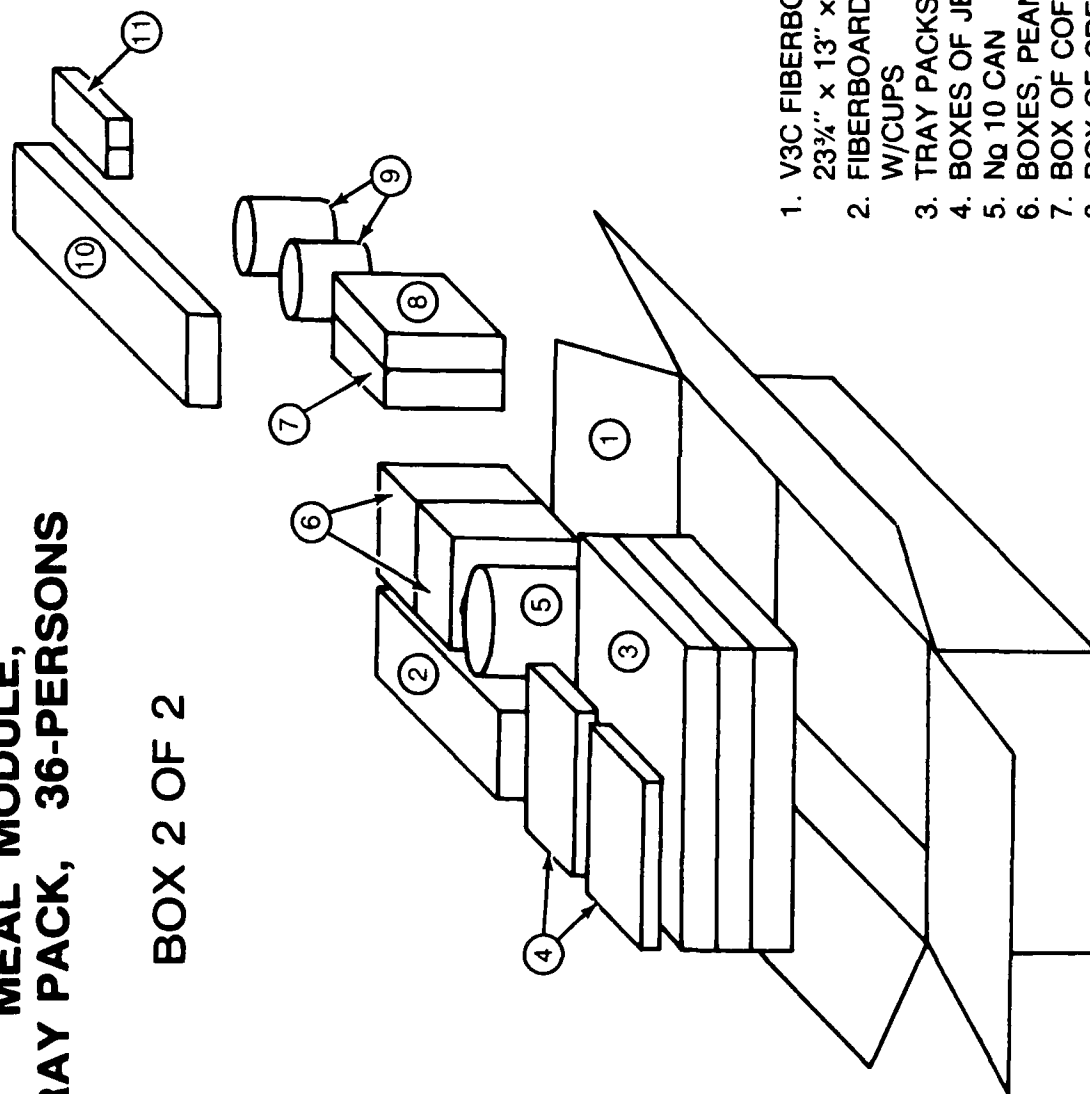
1. V3C FIBERBOARD BOX RSC-L
23 3/4" x 13" x 8 3/4"
2. FIBERBOARD AIR CELL C-3
W/CUPS
3. TRAY PACKS W/FIBERBOARD PADS
4. BOX OF COFFEE PACKETS
5. BOX OF CREAMER PACKETS
6. BOXES, PEANUT BUTTER PACKETS
7. BOXES, JELLY PACKETS
8. FIBERBOARD AIR CELL C-2
9. FIBERBOARD BOX, V3C, RSC
8 3/8" x 6 1/4" x 12 1/2" - CONTAINS
1 #10 CAN, 2 2 1/2 CANS AND
HOT SAUCE

EXPANDABLE BOX
6 TRAY BREAKFAST

Figure B-2. Meal Module, Tray Pack, 36-Persons, Expandable Box -- 6 Tray Breakfast

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 2 OF 2



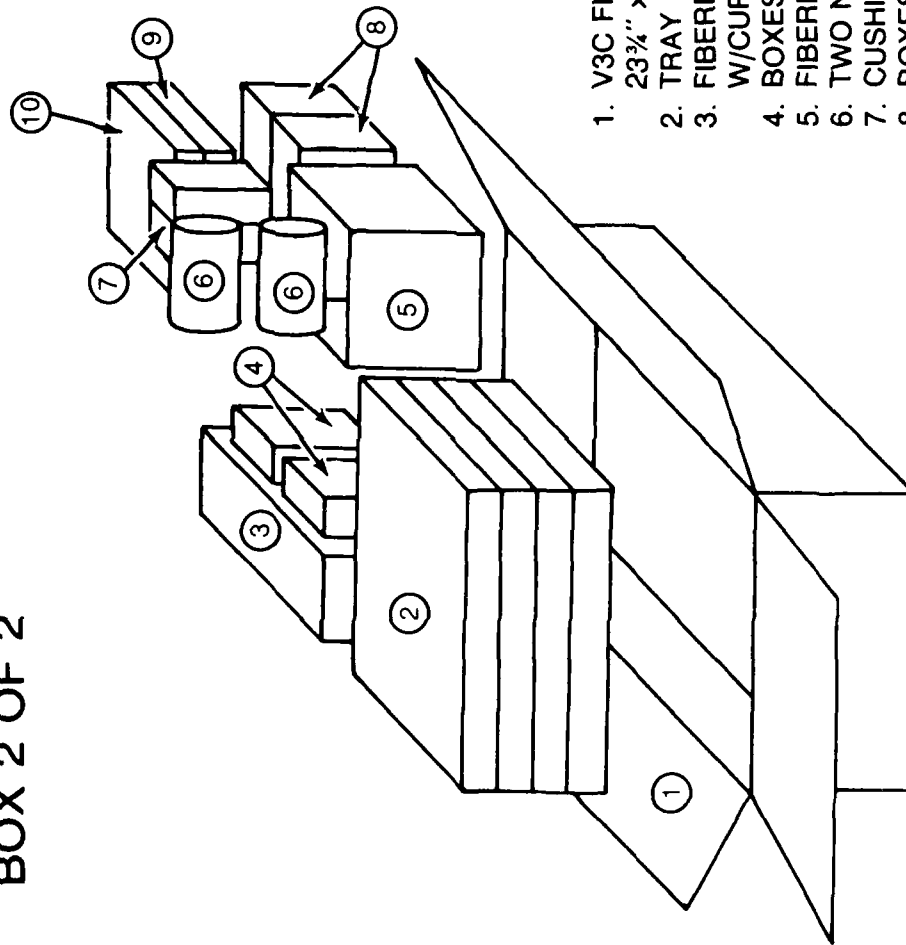
1. V3C FIBERBOARD BOX RSC-L
23 $\frac{3}{4}$ " x 13" x 8 $\frac{3}{4}$ "
2. FIBERBOARD AIR CELL C-3
W/CUPS
3. TRAY PACKS W/FIBERBOARD PADS
4. BOXES OF JELLY
5. No 10 CAN
6. BOXES, PEANUT BUTTER PACKETS
7. BOX OF COFFEE PACKETS
8. BOX OF CREAMER PACKETS
9. TWO No 2 $\frac{1}{2}$ CANS
10. FIBERBOARD AIR CELL C-4
11. CUSHIONED HOT SAUCE

EXPANDABLE BOX
7 TRAY BREAKFAST

Figure B-3. Meal Module, Tray Pack, 36-Persons, Expandable Box -- 7 Tray Breakfast

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 2 OF 2



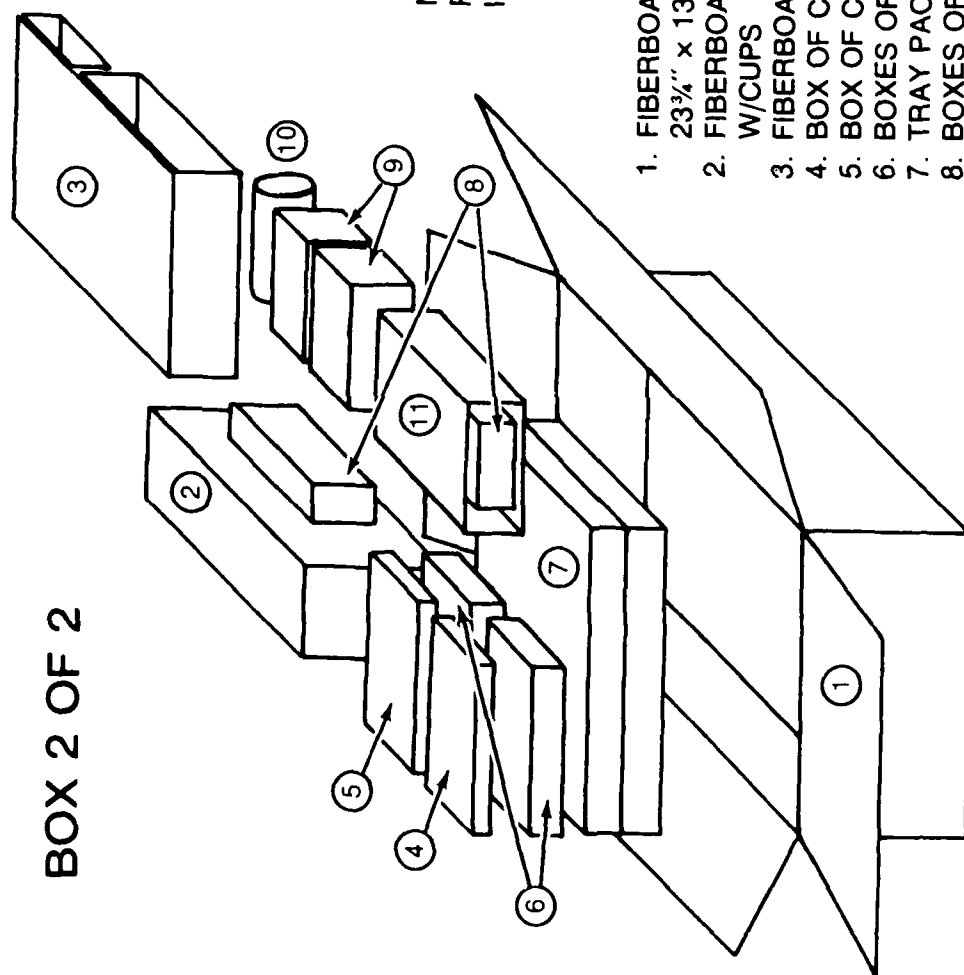
1. V3C FIBERBOARD BOX RSC-L
23 3/4" x 13" x 8 3/4"
2. TRAY PACKS W/FIBERBOARD PADS
3. FIBERBOARD AIR CELL C-3
W/CUPS
4. BOXES OF JELLY PACKETS
5. FIBERBOARD AIR CELL C-1
6. TWO No 2 1/2 CANS
7. CUSHIONED HOT SAUCE
PACKETS
8. BOXES OF PEANUT BUTTER
PACKETS
9. BOX OF COFFEE PACKETS
10. BOX OF CREAMER PACKETS

EXPANDABLE BOX
8 TRAY BREAKFAST

Figure B-4. Meal Module, Tray Pack, 36-Persons, Expandable Box -- 8 Tray Breakfast

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 2 OF 2



NOTE: CUSHION AND
POSITION HOT SAUCE
IN SPACE AVAILABLE

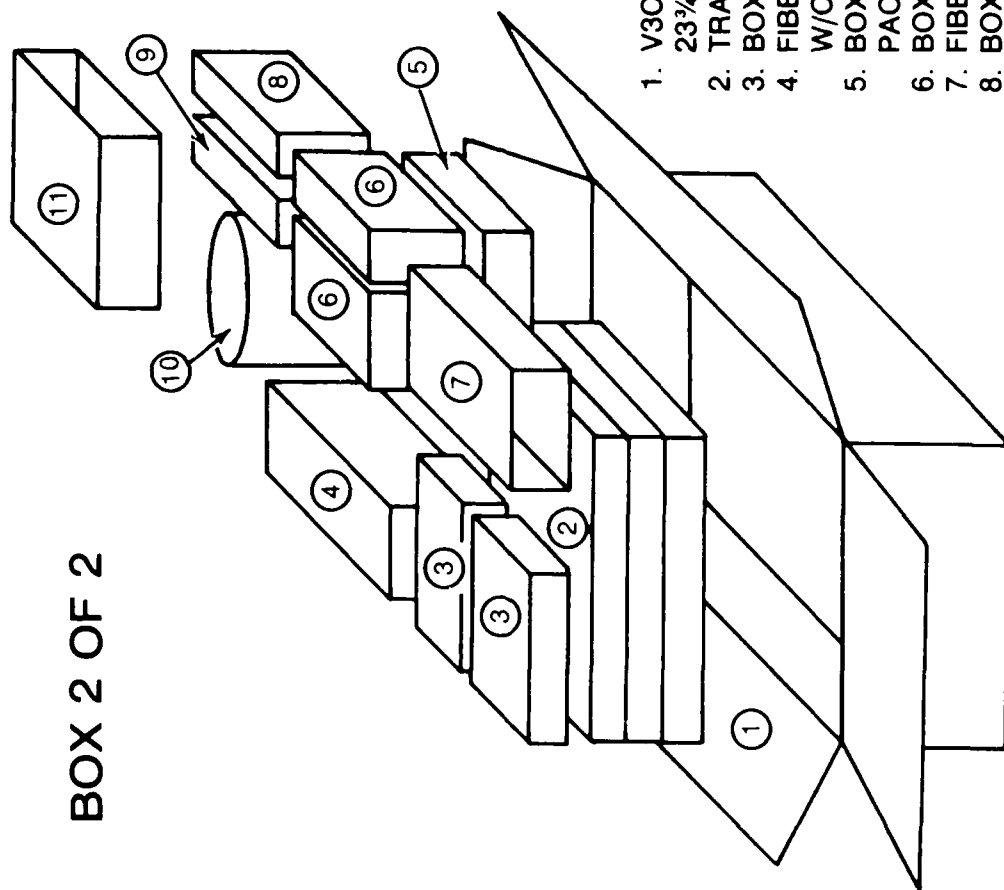
1. FIBERBOARD BOX - RSC-L V3C
23³/₄" x 13" x 8³/₄"
2. FIBERBOARD AIR CELL C-3
W/CUPS
3. FIBERBOARD AIR CELL C-6
4. BOX OF CREAMER PACKETS
5. BOX OF COFFEE PACKETS
6. BOXES OF BEVERAGE MIX
7. TRAY PACKS W/FIBERBOARD PADS
8. BOXES OF JELLY PACKETS
9. BOXES, PEANUT BUTTER PACKETS
10. ONE No 10 CAN
11. FIBERBOARD AIR CELL C-2

EXPANDABLE BOX
6 TRAY DINNER

Figure B-5. Meal Module, Tray Pack, 36-Persons, Expandable Box -- 6 Tray Dinner

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 2 OF 2



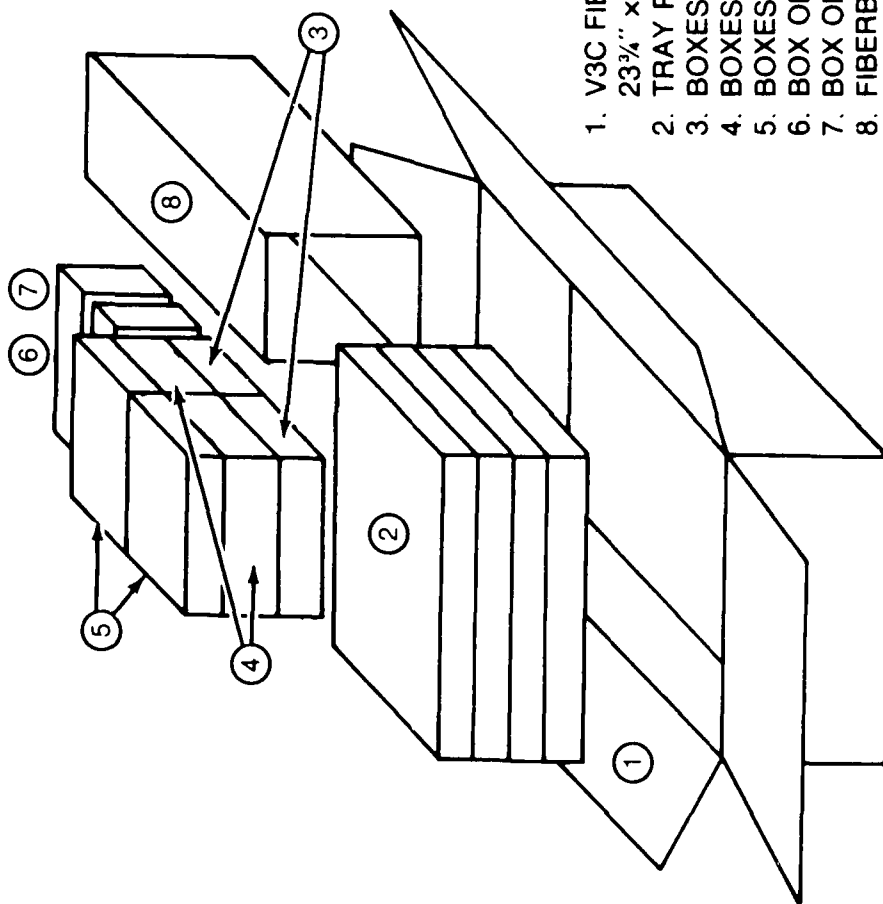
NOTE: CUSHION AND
POSITION HOT SAUCE
IN SPACE AVAILABLE

1. V3C, RSC-L FIBERBOARD BOX
23³/₄" x 13" x 8³/₄"
2. TRAY PACKS W/FIBERBOARD PADS
3. BOXES OF JELLY PACKETS
4. FIBERBOARD AIR CELL C-3
W/CUPS
5. BOXES OF PEANUT BUTTER
PACKETS
6. BOXES OF BEVERAGE MIX
7. FIBERBOARD AIR CELL C-7
8. BOX OF COFFEE PACKETS
9. BOX OF CREAMER PACKETS
10. ONE No 10 CAN
11. FIBERBOARD AIR CELL C-8

EXPANDABLE BOX
7 TRAY DINNER

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 2 OF 2



1. V3C FIBERBOARD BOX RSC-L
23 3/4" x 13" x 8 3/4"
2. TRAY PACKS W/FIBERBOARD PADS
3. BOXES, PEANUT BUTTER PACKETS
4. BOXES, BEVERAGE MIX
5. BOXES, JELLY PACKETS
6. BOX OF COFFEE PACKETS
7. BOX OF CREAMER PACKETS
8. FIBERBOARD AIR CELL C-9
WITH CUPS

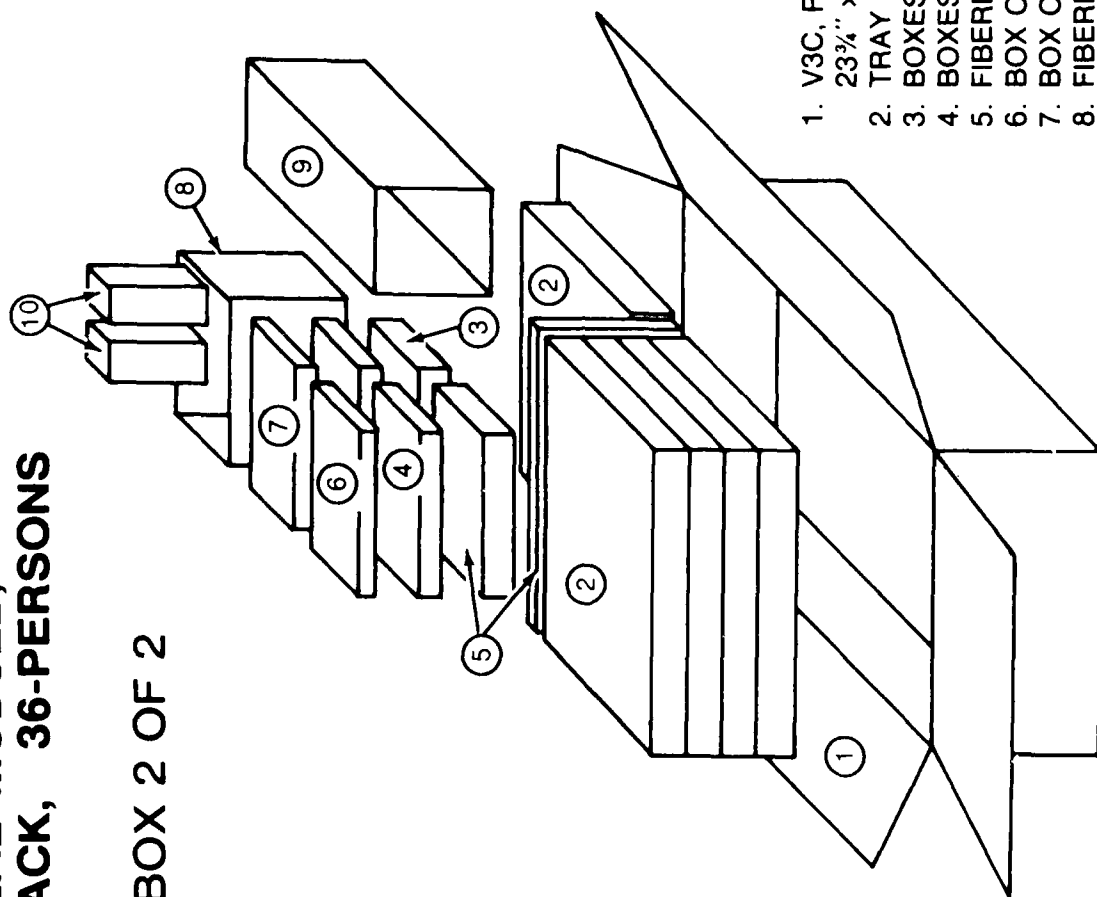
NOTE: CUSHION AND POSITION HOT
SAUCE IN SPACE AVAILABLE

EXPANDABLE BOX
8 TRAY DINNER

Figure B-7. Meal Module, Tray Pack, 36-Persons, Expandable Box -- 8 Tray Dinner

MEAL MODULE, TRAY PACK, 36-PERSONS

BOX 2 OF 2



1. V3C, RSC-L FIBERBOARD BOX
23 3/4" x 13" x 8 3/4"
2. TRAY PACKS W/FIBERBOARD PADS
3. BOXES, PEANUT BUTTER PACKETS
4. BOXES, JELLY PACKETS
5. FIBERBOARD PAD, 8 3/4" x 12 1/8"
6. BOX OF COFFEE PACKETS
7. BOX OF CREAMER PACKETS
8. FIBERBOARD AIR CELL C-11
9. FIBERBOARD AIR CELL C-10
W/CUPS
10. CUSHIONED HOT SAUCE

EXPANDABLE BOX
9 TRAY DINNER

Figure B-8. Meal Module, Tray Pack, 36-Persons, Expandable Box -- 9 Tray Dinner

APPENDIX C

Results of Airdrop Testing

APPENDIX C

Results of Airdrop Testing

INTRODUCTION

In the Combat Field Feeding System, the Kitchen Company Level Field Feeding (KCLFF) fills the void between the initial airborne assault and the air landing of the Mobile Kitchen Trailer. The KCLFF is designed to be airdropped. Because the Meal Module, Tray Pack, 36-Persons may have to be airdropped along with the KCLFF, airdrop rigging procedures for Low Velocity Airdrop (LVAD) and helicopter External Air Transport (EAT) using an A-22 cargo bag were developed and tested.

AIRDROP TESTING PROCEDURES

Testing was conducted in two phases. First, a Simulated Airdrop Impact Test (SAIT) was conducted at Natick to evaluate designed rigging procedures. Secondly, meal modules were shipped to the U.S. Army Airborne Special Operations Test Board, FT Bragg for actual airdrop of meal modules from a C-130 aircraft using the designed airdrop rigging procedures.

Acceptance Criteria. Seventy five percent (75) of all Tray Packs, #10 cans of fruit, beverages, cups, compartmented messtrays, and utensils must be usable after airdrop.

Simulated Airdrop Impact Test (SAIT). Meal modules were shipped from Defense Depot Tracy, CA to Natick. A 100% inspection of the contents was conducted. While pack and packaging varied slightly from the specified assembly procedures, it was determined to be sufficient and adequate. Other than minor handling damage, no deficiencies were noted. All nicks, dents and creases on ration components, pack, and packaging material were marked. In this manner, damage directly attributable to airdrop would be identified.

The Aero-Mechanical Engineering Directorate (AMED) designed and tested airdrop rigging procedures. The SAIT was conducted at a drop height of 7 feet to simulate a terminal velocity of 21 feet per second. Terminal velocity was determined for a load of weight of 1274 pounds and a foot print area of 5 square feet using a G-12D cargo parachute. Energy dissipation was designed for an impact deceleration level of about 21 Gs.

The SAIT was conducted on 24 February 1987. Immediate inspection of the load from an airdrop perspective indicated that the rigging procedures were satisfactory. Further inspection of the pallet load was performed with regard to all packaging, packing, and ration components. There was no major damage to any of the components that would render them unserviceable. No new dents or creases were found that differed from those marked in the pre-drop inspection. Immediately after the post-drop inspection, the modules were reassembled and placed in incubation for two weeks at an average temperature of 134.8 degrees F. This accelerated test was performed to detect any tray, can, and pouch leakers. None were found. Based upon the satisfactory results of the test, pallets of meal modules were shipped to the U.S. Army Airborn Special Operation Test Board or actual airdrop testing.

Airdrop of Meal Modules, Fort Bragg. A total of 3 pallets were dropped at Fort Bragg. The first pallet load was dropped by a C-130 aircraft with an airspeed of 130 knots from 500 feet. Wind velocity was 2-4 knots. Immediate inspection of the pallet indicated varying degrees of damage to the external containers. Upon 100% inspection of the pallet load, only one Tray Pack was noted to be slightly dented but usable. All other components sustained no damage.

The two remaining pallets were dropped from a C-130 aircraft with an airspeed of 130 knots from 600 feet. Again some external damage to the containers was identified. However, upon inspection only one Tray Pack leaker was noted while two other trays had moderate dents but were entirely useable. All glass, bottles, papergoods and other contents were found intact in every module inspected.

Conclusion. Results of both the SAIT and airdrop from C-130 aircraft indicate that the pack and packaging of the meal modules is sufficient to withstand LVAD and EAT airdrop using the developed rigging procedures.

APPENDIX D

Rigging Procedures for Low Velocity Airdrop (LVAD) of the
Meal Module, Tray Pack, 36-Persons in an A-22 Cargo Bag

APPENDIX D

Rigging Procedures for Low Velocity Airdrop (LVAD) of the Meal Module, Tray Pack, 36-Persons in an A-22 Cargo Bag

1. LOAD DESCRIPTION.

The Meal Module, Tray Pack, 36-Persons, consists of fiberboard containers strapped together as one. Twelve (12) modules are rigged on a pallet in an A-22 container using one G-12D cargo parachute. Each module measures 23-3/4 inches long, 13 inches wide, 17-1/2 inches high and weighs approximately 96 pounds. The pallet measures 40 inches long, 48 inches wide, 41 inches high and weighs approximately 1,060 pounds.

2. LOAD PREPARATION.

a. Cut a 3/4 by 48 by 53 1/2-inch piece of plywood to be used as a skid. Drill two 1/2-inch-diameter holes in each corner. These holes are 3 inches inboard from the nearest edge and 8 inches apart. Thread a 6-foot length of 1/2-inch tubular nylon or doubled Type III nylon cord through the holes in each corner of the skid.

b. Prepare, position, and glue the base honeycomb stacks (5 stacks, 3 layers each, 3 by 12 by 12 inches) to the A-22 skid shown in Figure D-1.

c. Prepare, position, and glue a 3/4 by 40 by 48-inch piece of plywood (load spreader) on top of the honeycomb stacks.

d. Center an A-22 cargo sling and cargo cover on top of the plywood.

e. Position the pallet of 12-meal modules on the cargo cover as shown in Figure D-2.

f. Position a 3 by 40 by 48-inch piece of honeycomb on top of the pallet as a load cover.

g. Close the A-22 cargo bag and sling assembly according to procedures in FM 10-501/TO 13C-1-11.

3. PREPARING AND ATTACHING CARGO PARACHUTE.

Prepare and attach one G-12D cargo parachute according to procedures in TM 12-1670-215-23/TO 13C5-1-102 and FM 10-501/TO 13C7-1-11, respectively.

4. RIGGED LOAD DATA.

Length	48 inches
Width	53 1/2 inches
Height	64 inches
Weight	1274 pounds

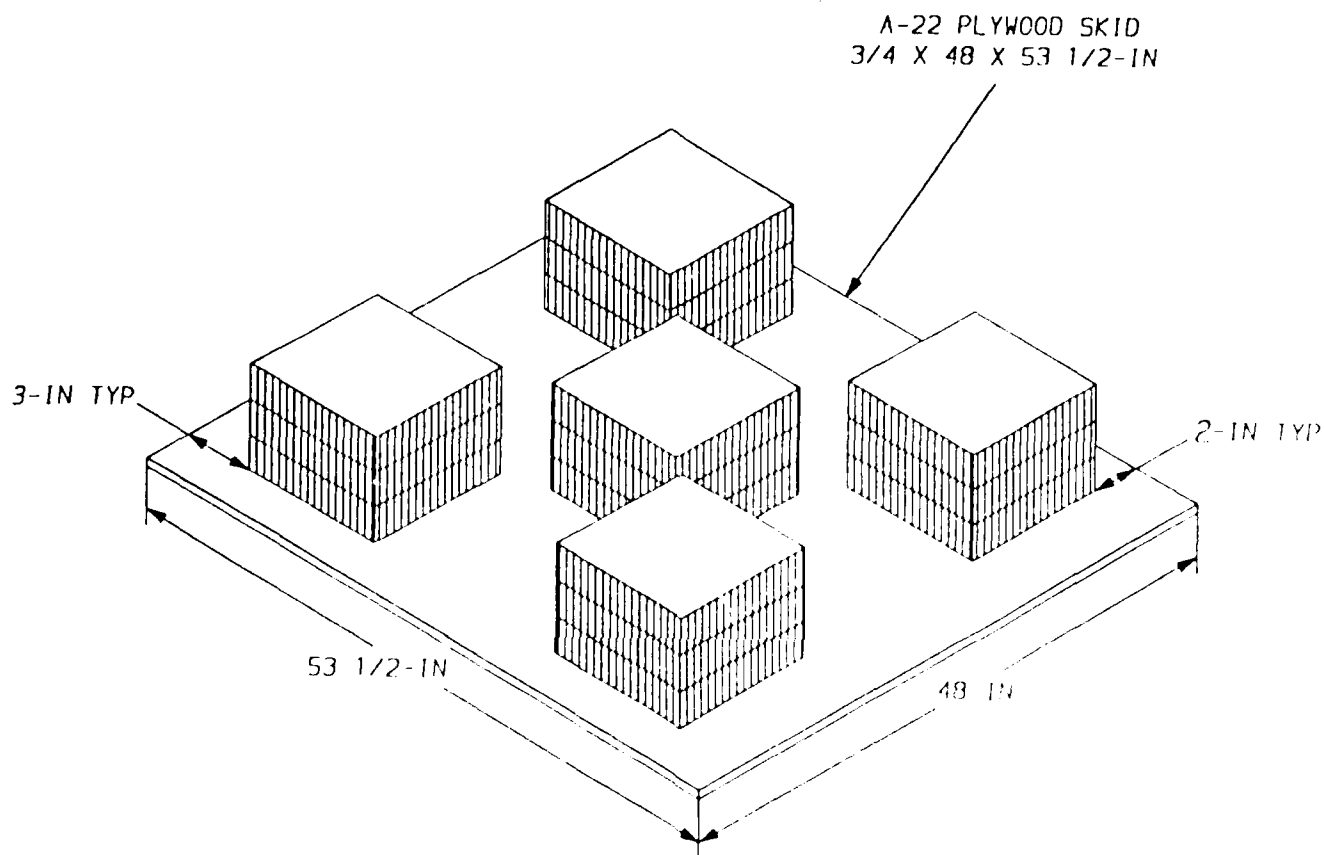


Figure D-1. LVAD A-22 Honeycomb Configuration for the Meal Module, Tray Pack, 36-Persons

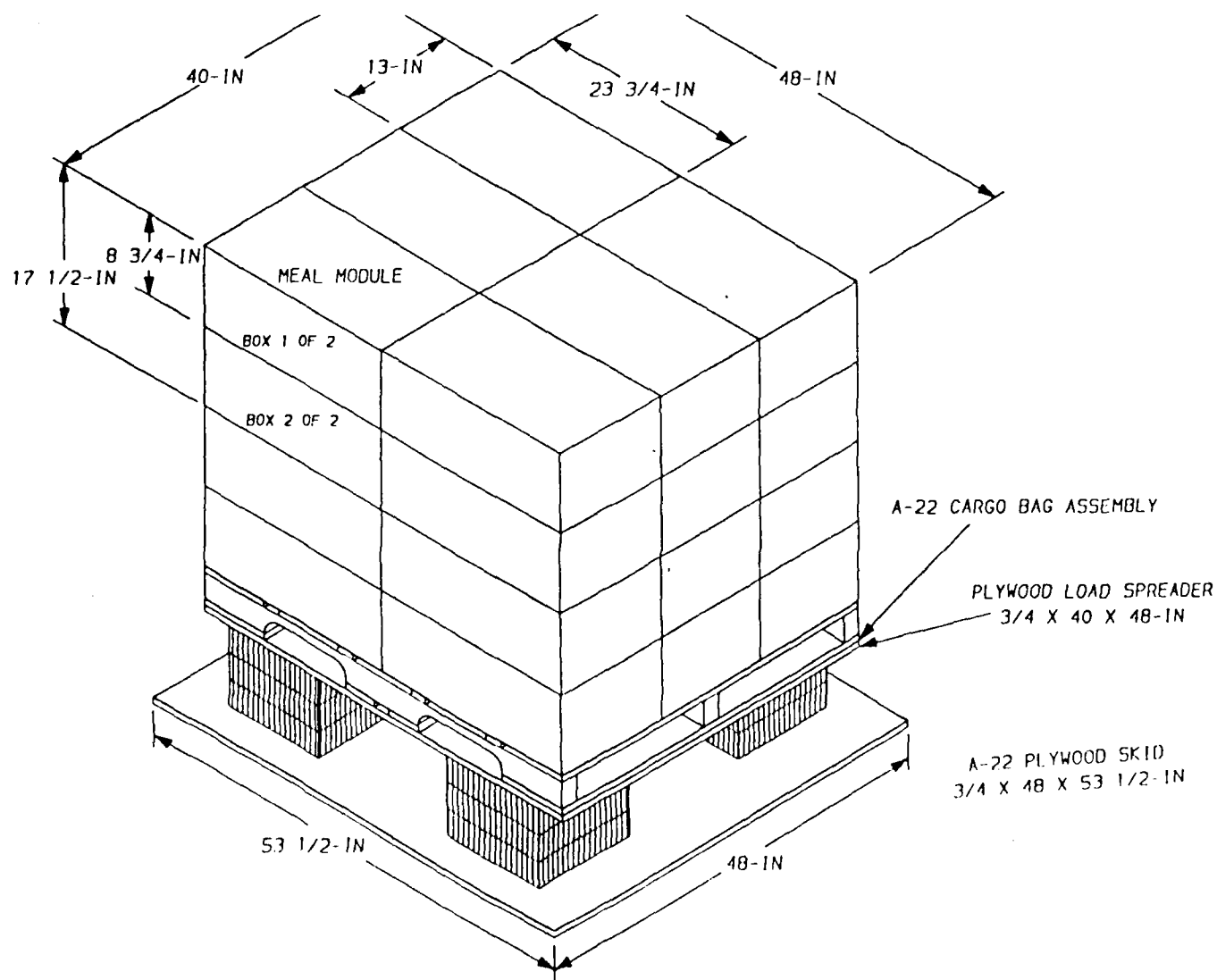


Figure D-2. LVAD A-22 Stacking Configuration for the Meal Module, Tray Pack, 36-Persons

APPENDIX E

External Air Transport (EAT) Procedures for the
Meal Module, Tray Pack 36-Persons

APPENDIX E

External Air Transport (EAT) Procedures for the Meal Module, Tray Pack 36-Persons

1. APPLICABILITY.

This load is suitable for the UH-1H helicopter.

2. LOAD DESCRIPTION.

a. One shipping pallet of 12 pairs of the meal module fiberboard containers, measuring 40 inches long, 48 inches high, and 41 inches wide.

b. Weight: 1,060 pounds

3. PREPARATION.

None. Ensure that the shipping pallet is properly banded and in serviceable condition.

4. RIGGING.

a. Materials:

(1) One Net, Cargo, Nylon, 5,000-Pound Capacity
(NSN 1670-01-058-3811)

(2) One Sling Assembly, 10,000-Pound Capacity
(NSN 1670-01-027-2902)

(3) Webbing, Nylon, Tubular, 1/2-Inch (NSN 8302-00-082-5752)

b. Procedures.

(1) Spread the cargo net and position the pallet of meal modules in the center of the net.

(2) Place all four lifting legs on top of the load.

(3) Attach all four metal hooks to the apex fitting.

(4) Tie the net around the top of the load with the 1/2-inch tubular webbing.

(5) Place link #3 of the sling leg in the grabhook.